JUN 20 1931

Testing Machines and Apparatus Issue

INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

(Reg. U. S. Pat. Off.)

Devoted to Measurement and Control Problems

Vol. 4. No. 6 Pittsburgh, Pa. June, 1931

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Editorial Comment

★

First Exhibit of Testing Apparatus and Machines

★

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J. T. Nichols

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New Instruments

- New Potentiometer Pyrometer
- New Tapalog Recording Pyrometers
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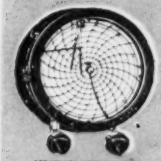
- Stretch and Shrinkage Testing Apparatus
- New Measuring Microscopes
- Elasticometer Spring Testing Machine
- Automatic Oscillograph
- Ice Cream Over-run Auto-Gage
- Piston Ring and Valve Spring Auto-Gage
- The Most Powerful X-Ray Tube

Place initials of interested persons in your organization opposite title and call it to their attention.

Circulation of this issue over 12,000

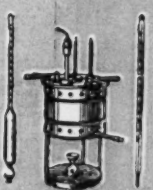
RECEIVING THERMOMETERS AND PRESSURE GAGES



RECORDER - CONTROLLERS

AUTOMATIC CONTROLLERS

DIAL - INDICATING THERMOMETERS



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ESPECIALLY prepared in response to urgent and repeated requests from chemists, inspectors and TAG users everywhere, you will find these catalogs of inestimable and practical value.

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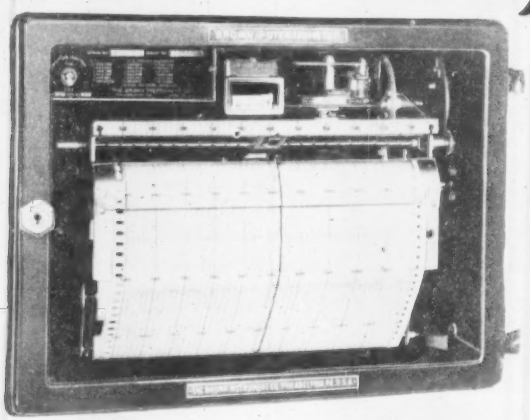
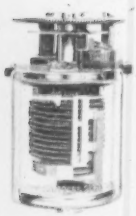
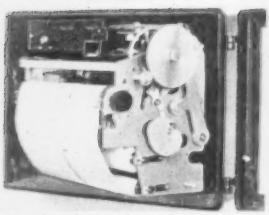
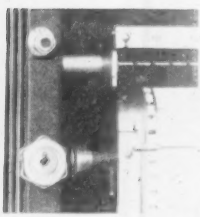




Extra Long Slide Wire—40 Inches—And rheostat for standard cell balancing, enclosed in glass and immersed in oil, protected from corrosion.



Positive Non - Slip Driving Clutch—Rugged, positive and simple. Entire mechanism on swinging frame. Note also chart reroll.



Door Handle with Lock and Key for Use if Desired, also Outside Control Setting—Control temperature set by external knob

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The new Brown Potentiometer Pyrometer was developed by years of research to meet a definite industrial need. It is primarily an industrial instrument, designed for service under severe plant conditions, yet it has the highest accuracy.

More than fifty features new in potentiometer pyrometers are embodied in its design. Many of these features are vital to greater accuracy in temperature measurement. Get full information in Catalog No. 1101.

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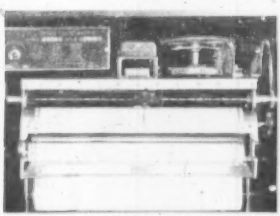
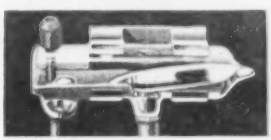
Branches in 22 principal cities

Get this 48-page Catalog No. 1101 describing over fifty important features of the Brown Potentiometer Pyrometer. Copy sent on request.



Humidity Compensator for Chart — Automatically compensates for possible errors caused by paper expansion and contraction.



Mercury in Glass Switches for Automatic Control—Controller operates mercury switches, eliminating relays. No open arcs.

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Accuracy to Industry

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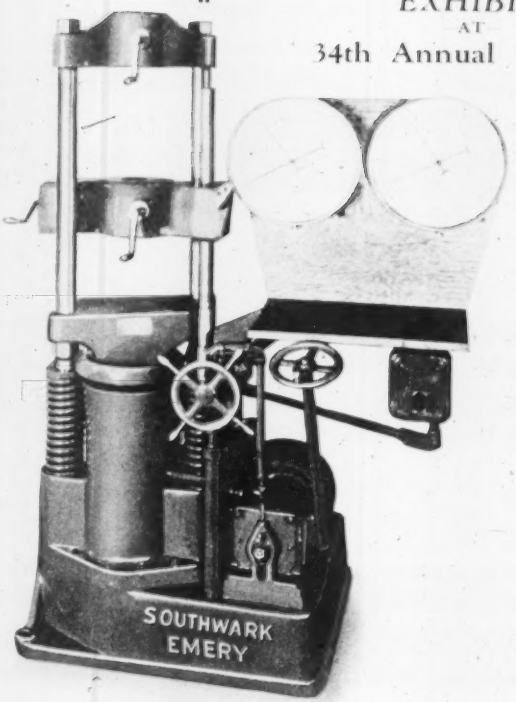

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Literature
upon request

The 60,000 lb. Southwark-Emery Universal Testing Machine shown above will be there as well as numerous other examples of Southwark's line of testing equipment.

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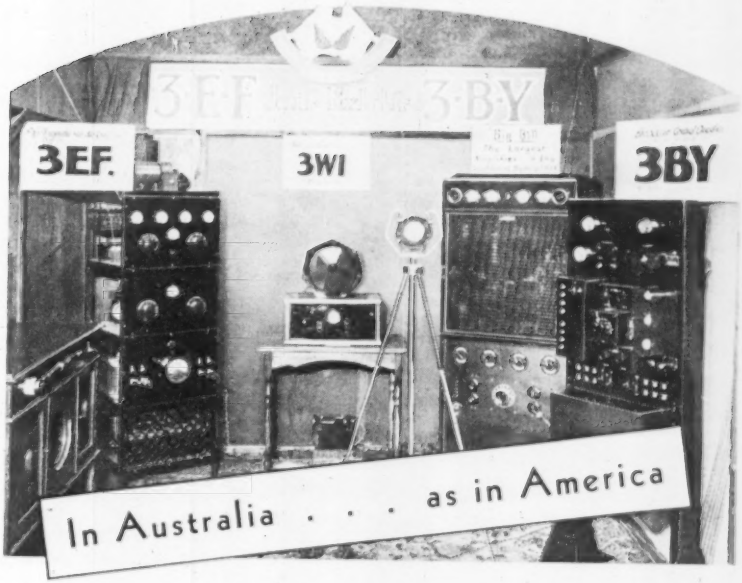

WESTON METERS !

are Preferred . . .

● On the other side of the world, the Wireless Institute of Australia controls the activities of the radio transmitting amateurs as the Radio Relay League does in America.

▼

The Wireless Institute of Australia, at a recent Wireless Exhibition held at Melbourne, showed some of their representative equipment: the transmitter of the Wireless Institute's official station 3WI, using six Weston 3¼ inch meters; BIG BILL, the Philips Amplifier, manufactured in Holland and claimed to be the largest in the Southern Hemisphere, using four 3¼ inch Weston meters; the transmitter of 3BY, winner of numerous contests and recognized to be the best amateur station in Australia, using three 3¼ inch Weston meters.

▼

The predominance of Weston meters on this Australian equipment is typical of the preference for Weston meters on transmitting panels and for the many other radio uses.

There is a Weston instrument for every electrical testing and measurement requirement.

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New Hydraulic Universal Tester

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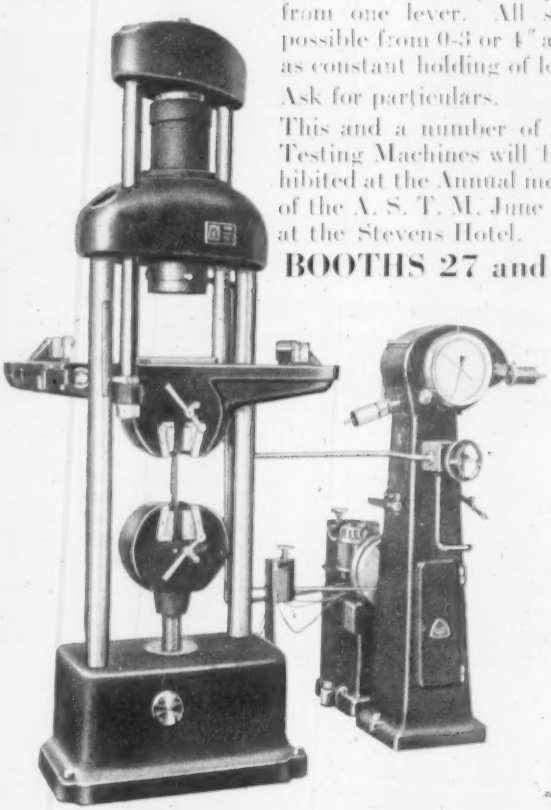
Ask for particulars.

This and a number of other Testing Machines will be exhibited at the Annual meeting of the A. S. T. M. June 22-26 at the Stevens Hotel.

BOOTHS 27 and 29



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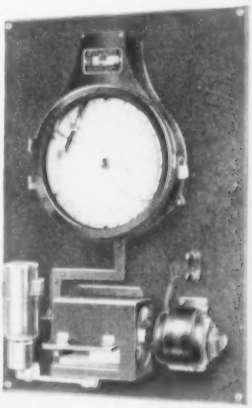
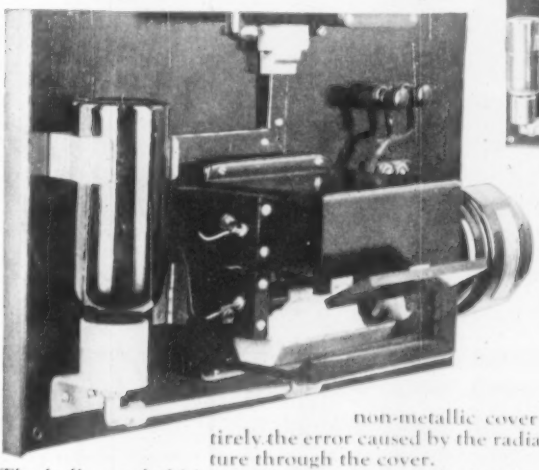
New Wet and Dry Bulb Thermometer Fixture

A NEW Wet and Dry-Bulb Thermometer Fixture, recently placed on the market by The Bristol Company, eliminates, to a large degree, the errors common in such devices.

In the past, it has been the practice to enclose the wet bulb with a metal cover and circulate air over the bulb by means of a fan and motor. With this equipment, the wet bulb depression was always less than the depression as obtained with a standard sling psychrometer. The results were always disappointing; that is, the greater the depression the greater the error.

A *non metallic* cover has been used on the new fixture, arranged to have around the bulb a large amount of space for the circulation of air. This non-metallic cover eliminates almost entirely the error caused by the radiation of room temperature through the cover.





Above is shown complete panel, including Recording Instrument, motor, fan, bulb housing and bottle of water. At left is a close-up of the new fixture.

The bulbs are held in position by non-metallic brackets so that the temperature of these brackets cannot affect the bulb temperatures.

The water pan is shallow and wide so that a large surface of water is exposed to the circulating air. This causes the water to evaporate from its surface and thus cooling it to a temperature near the wet bulb temperature. In this way water of the proper temperature is supplied to the bulb.

No soft soldered joints are supplied in the water system so that water corrosive to solder can be used.

Results from this wet and dry bulb fixture are very close to the standard sling psychrometer.

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for industrial purposes
and laboratory tests.

ASKANIA

Glass Strain Viewers, a useful
tool for the manufacturer and
purchaser of glass articles.

Askania Vibration Meters with record-
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Ask us for further details on our equipment or better
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AMERICAN ASKANIA CORPORATION
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Use Hoke-Phoenix Controls

for compressed gases

Reducing-valves Needle-valves Flo-gages Valvo-gages they save your time and improve your results. For all kinds of gases, all kinds of tanks O_2, H_2, CO_2, NH_3, etc. Sturdy and inexpensive.

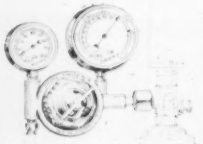
Shall we send you one on approval?

We also make up special designs and combinations on request.

Valvo-gage

On display at Emil Greiner's booth, A. S. T. M. exhibit

Ask for folder RJ.



A Hoke-Phoenix Reducing Valve gives you just the pressure and volume desired.

When working Pyrex or quartz glass, use a Hoke oxy-gas burner. Several models.

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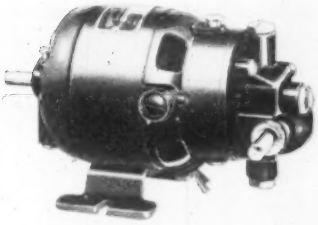
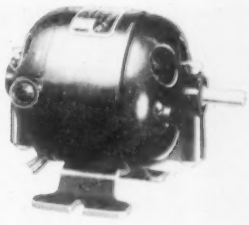
for Every Application





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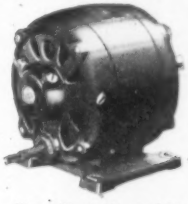
with and without Speed Reducers

These motors are ideal for driving small fans, air pumps, centrifuges, timing devices, therapeutical apparatus, projectors, and hundreds of other laboratory and industrial devices. Ratings without speed reducers 1/30 to 1/15 H. P.

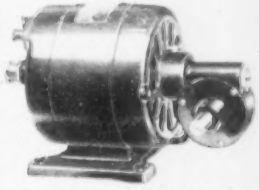
With speed reducers the ratings are 1/30 to 1/50 H. P. The gear ratios range from 3½-1 to 1120-1. These motors solve many difficult design problems and reduce manufacturing costs. Send for Bulletin 1002-C describing these motors.

Other Bodine Motors for Laboratory and Industrial Service



Type N, A. C. and D. C. Constant Speed Motors with wool packed bearings. Rated from 1/20 to 1/8 H. P. Send for Bulletin No. 1006-B.

Universal Laboratory Motor with Speed Regulator for 110 volt A. C. or D. C. service. Extremely flexible. Send for Bulletin No. 1005.



Types SAR and SDR Constant Speed A. C. and D. C. Motors with speed reducers. 1/30 to 1/12 H. P. Also Synchronous. Bul. No. 1011.

Leading instrument manufacturers have adopted Bodine standard and special motors for their equipment.

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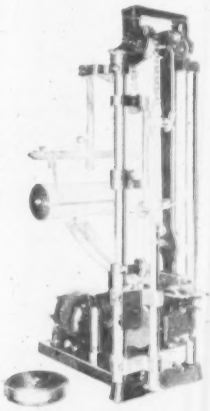
Desk Model, Motor Driven
Automatic Operation and Control
Double Capacity Ranges
Graphic Recording Unit

Tensile Strength is indicated directly on graduated scales. Recording Unit shows graphic picture of Tensile Strength, Elongation, proportion of Elongation to increasing load, etc.



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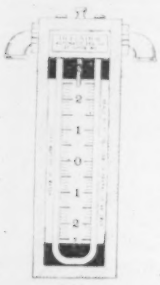
Standard Testing Scales for paper, paperboard, cordage, roofing, asbestos, foil, etc.
Gauge Testing Outfits
Hand Tachometers, Tachoscopes
Stationary Tachometers (both Indicating and Recording)

Amthor Testing Instrument Co., Inc.

315A Johnson Street Brooklyn, N. Y.



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A Type for Every Purpose

Bulletin No. 38 illustrates 4 models in two lengths of these cover type U Gauges with 4 standard scales reading in Pounds and Ounces, Inches and Tenths using Water, Mercury, Red Oil or Tetrabromide for reading pressure, Vacuum or differential in low pressure. Bulletin No. 36 illustrates a complete line of high and low pressure Single and Double leg column Manometers with any type of scales for any purpose. We also make a complete line of Instruments and Regulators, including Combustion Control systems and Efficiency Instruments for Boilers.

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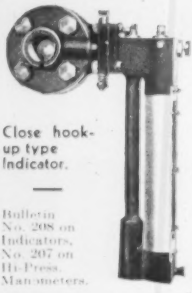
St. Louis, Mo.



Close hook-up type Indicator.

Bulletin No. 208 on Indicators, No. 207 on Hi-Press. Manometers.

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Continuously and accurately indicate flow of water, oils, chemicals, air, gas and steam under pressures up to 1000 lbs.

Direct Reading - Accurate - Compact

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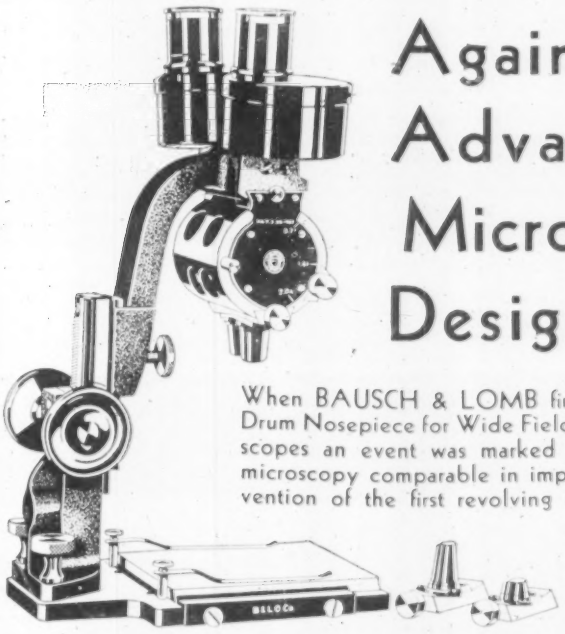

Again B&L Advances Microscope Design » »

When BAUSCH & LOMB first announced the Drum Nosepiece for Wide Field Binocular Microscopes an event was marked in the history of microscopy comparable in importance to the invention of the first revolving nosepiece. Now comes the first radical improvement in the Drum Nosepiece . . . another historical milestone.

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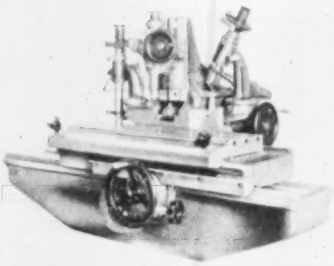

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For Measuring Surface Temperatures

"Alnor" Pyro Lance

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Furnished with or without automatic cold end compensator in two sizes.

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"Standarized Weathering"

as an instrument for measuring weathering effects upon any tested samples is today quite as well recognized in laboratory and industry as are any of the other instruments known for the measure, test and check of physical and chemical properties. The instrument that gives this standardized weathering is Weather-Ometer—the only machine of its kind in the world today. Its use is general wherever preknowledge of weathering reaction is required. We will gladly detail these uses—discuss with you its application to your own needs. Ask for Bulletin I-6.

By the Makers of Fade-Ometer and Launder-Ometer.

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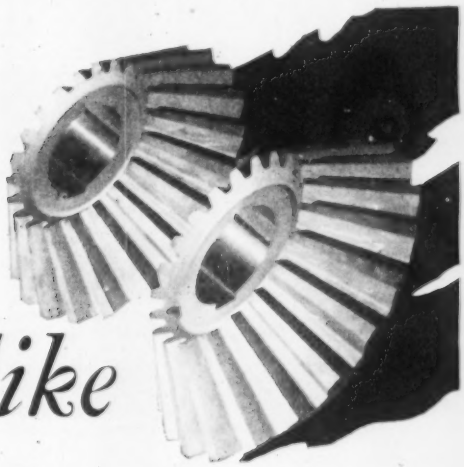
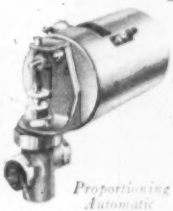


They look alike

but their production is two different stories



Proportioning Automatic Electric Motor Control Can instantly move valve or other driven mechanism to new position on slightest control changes. Assures amazingly constant temperature, pressure, liquid level, rate of flow, humidity, etc.

Motorized globe and butterfly valves

Two different shops furnished these identical units—part of an order for an exacting customer.

Both made the grade with the customer's inspector. Both are quality castings—free from flaws and defects. They *look* alike.

But their histories are *not* alike.

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Minneapolis-Honeywell has helped many industries to change from the No. 1 to the No. 2 basis of doing business. Minneapolis-Honeywell makes a complete line of sensitive controllers that react instantly to variations in pressures and temperatures—and motor valves that regulate the flow of gas, oil, water, air or steam.

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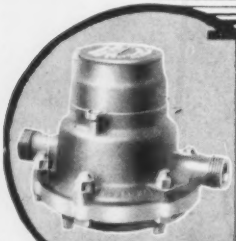

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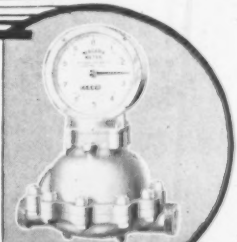

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INDEX CARD SECTION

A file card index will be a valuable asset. It is suggested that this index information be cut out, mounted on cards, and filed in your desk or in a file box on top of your desk. You will then have within easy reach an index of instrument information of incalculable value.

First Exhibit of Testing Apparatus and Machines

INSTRUMENTS, Vol. 4, No. 6, June 1931, pages 299-306, 2 figs.

Article gives information on machines and apparatus, which will be exhibited.

An Ideal Tensile Testing Machine

J. T. NICHOLS, INSTRUMENTS, Vol. 4, No. 6, June 1931, pages 307-308

The ideal tensile testing machine is described.

Timing and Scheduling Instruments

M. F. BEHAR, INSTRUMENTS, Vol. 4, No. 6, June 1931, pages 309-352, 60 figs.

Conclusion of Chapter XIV of Handbook of Industrial Instruments: Section 3—Time Indicators; Section 4—Time-Recorders; Section 5—Single Duty Controllers; Section 6—Sequencing Controllers; Section 7—Condition Time Curve Controllers; Section 8—Combination Controllers.

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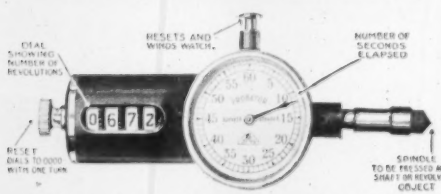
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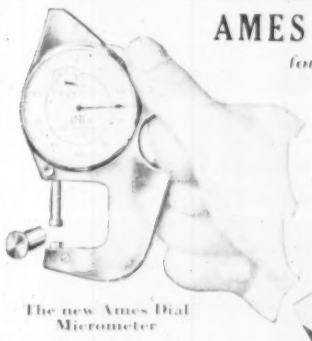

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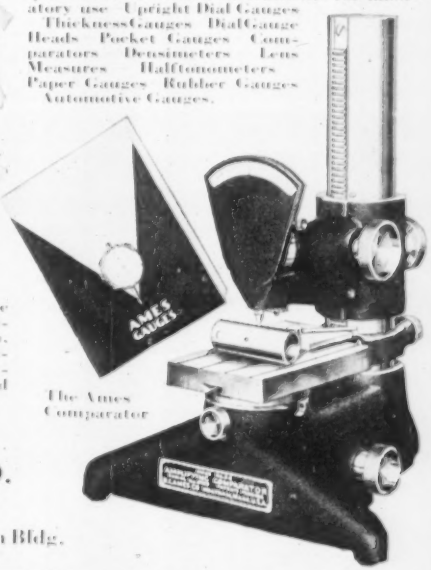

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Taylor Instrument Cos., 95 Ames St., Rochester, N. Y. Inside Back Cover

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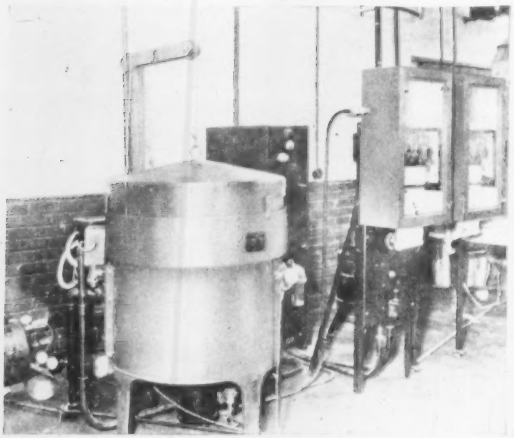
Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark, N. J.

Homo Nitriding Furnace



The Ex-Cell-O Aircraft & Tool Corp. Uses this Homo Nitriding Furnace

EX-CELL-O *Uses This Modern Hardening Process and Equipment*

The Nitriding Process—the latest method for surface-hardening parts requiring maximum resistance to abrasive wear—makes special demands on equipment that are fully met by the Homo Nitriding Furnace.

This special Homo Furnace—complete, automatically controlled, efficient—puts the variable factors of this new process under control; enables hardeners to specify quality desired and be *certain of securing it.*

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Bulletin No. 950-I gives complete details and shows installations in well known plants. Send for it.

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PHILADELPHIA CLEVELAND CHICAGO
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Richard Rimbach, Managing Editor **M. F. Behar**, Engineering Editor

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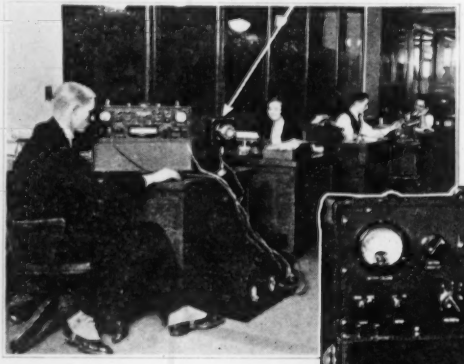
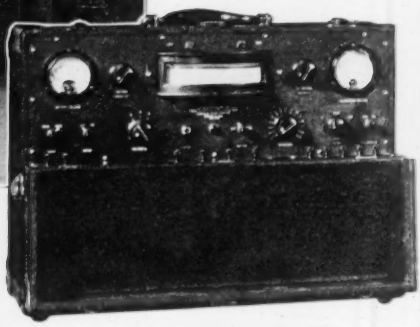
QUICK - ACCURATE MEASUREMENTS of SOUND AND VIBRATION with the BURGESS ACOUSTIMETER





Left: Measuring office noises by means of the Burgess Acoustimeter shown below. Arrow indicates microphone.

THIS instrument and other new Burgess-Parr Products will be exhibited in booths Nos. 20 and 22 of the A. S. T. M. Exhibit of Testing Apparatus and Machines.

Ask or write for Bulletin No. E-9

BURGESS-PARR COMPANY
DIVISION OF C. F. BURGESS LABORATORIES INC.
111 WEST MONROE STREET
CHICAGO, ILLINOIS

When writing to the above company, please mention INSTRUMENTS

EDITORIAL COMMENT

In this issue . . . we inaugurate a much-needed Employment Service for instrument men. See below.

In this issue . . . which will appear shortly before the first Exhibit of testing instruments, this important event and the A.S.T.M. Convention of which it forms part, are featured. See pages 299 to 306.

In this issue . . . J. T. Nichols describes in delightfully interesting detail his idea of an (or "The") ideal tensile testing machine. To our way of thinking, he merely describes what will eventually be a commonplace. See page 307.

In this issue . . . M. F. Behar scores another timely scoop in presenting the first comprehensive treatise on industrial timing instruments. It was high time someone tackled this job, but though a first-time job it has the earmarks of a ten-times revised classic. See pages 309 to 352.

In this issue . . . a number of new instruments are described; books are reviewed; new booklets are announced, and advertisers, in honor of the A.S.T.M., feature their new testing instruments.

To Bring Men and Jobs Together

IN normal times, competent instrument men—from glass blowers and other artisans to pyrometer designers and to engineers able to run instrument departments in large plants—seem to be as scarce as hen's teeth. We remember that before the depression there was talk of getting Washington to make exceptions to the contract-labor law and to the quota law in favor of certain classes of artisans, technicians and physicists whose need was keenly felt by instrument makers and by instrument using plants.

At present the situation is altered. We don't mean to imply that there is a surplus of competent instrument men, for that is not so. There is going on, however, a basic re-alignment of industries, of corporations within industries, of plants within corporations and of departments within plants. In the confusion and excitement, there are hundreds of cases where the forces set into play by the industrial re-alignment compel drastic reductions in various departments and plants—even compel shutting down entire establishments. Thus it comes about that in a period that calls more than ever for the benefits of Instrumentation, many instrument men suddenly find themselves out of work through no fault of theirs or of their immediate employers. But in additon to these hundreds of cases that the public hears about, numerous unwise decisions are being made every day. We refer to throwing out trained engineers, research workers and laboratory technicians and either attempting to fill their places without hiring new men, or hiring an equal number of men at less pay. Such decisions, inspired by fear or greed, are not only unwise but inhuman.

Whatever the causes, there are now available the services of hundreds of splendidly equipped instrument men. On the other hand, since a period of

industrial depression enhances the value of Instrumentation, the logical value of these men's services is appreciated more than ever, and wise industrialists are on the lookout for them.

Good instrument men looking for jobs . . . and responsible instrument obs looking for good men.

Clearly a situation calling for something to be done. But by whom?

Instruments does not pretend to be the "official organ" of any industry or of any group of men. Still, it occupies a rather focal position: Corporations with instrument jobs to fill have asked *Instruments* for men; and unemployed instrument men have asked *Instruments* to put them in touch with jobs.

Running an employment agency was not part of our plan as publishers, but in attending to these requests it became evident that *Instruments* was looked upon as such. Very well, we accept the nomination. But only on one condition; that we are to derive no financial profit. This stipulation being laid down, we are happy to announce the inauguration of a free employment service for instrument specialists. The details appear below, as well as several notices of pending cases.

INSTRUMENTS EMPLOYMENT SERVICE

No charge for insertion of notices, which should be addressed to *Instruments* Employment Service, 3619 Forbes Street, Pittsburgh, Pa., should be written tersely and must be received by the 25th of the month. In replying, do not fail to put identification number on *both* envelope and letter.

MEN AVAILABLE

INSTRUMENT MAKER: 7 years experimental laboratory of electrical company. J-1.

INSTRUMENT MAKER: 3½ years experimental laboratory of lamp company; 2 years experimental laboratory of electrical company. J-2.

PYROMETER MAN: Graduate Pennsylvania State College. Had charge of pyrometer calibration laboratory in plant with 1100 pyrometers. J-3.

METALLURGIST: 1½ years University of Pennsylvania; 7 years night school Carnegie Institute of Technology. 2 years steel plant analyst; 7½ years plant metallurgist in foundry. Can read German, Polish, Bohemian and Russian. J-4.

METALLURGIST: Graduate University of Pittsburgh; 5 years steel plant metallurgist; 6 years sales metallurgist; 3 years metallurgist automotive plant. J-5.

As we go to press we learn with regret that Prof. Samuel Wilson Parr, President Burgess-Parr Co., Moline, Illinois, died at his home in Urbana, Illinois, Saturday, May 16, 1931.

Arthur Schroder, formerly Director of Technical Service of the Fisher Scientific Company, has become identified with the development staff of the Aluminum Company of America.

Illinois Testing Laboratories, Inc., 141 W. Austin Avenue, Chicago, Illinois announces the appointment of Ernest H. Du Vivier, 30 Church Street, New York City, its representative in Metropolitan New York and northern New Jersey and F. W. Fernald of 335 Fifth Avenue, Pittsburgh, Pa. as its representative in Western Pennsylvania and West Virginia for its line of portable and Stationary Pyrometers, Resistance Thermometers and other measuring instruments for industrial uses.

THE A. S. T. M. CONVENTION AND INSTRUMENTS EXHIBIT

THE exhibit of testing apparatus and machines to be held at the Stevens Hotel in Chicago in conjunction with the 34th annual meeting of the American Society for Testing Materials, June 22 to 26, will really be the first large-scale Instrument Show. Testing instruments will dominate and visitors will, we believe, be saying for months, "I saw it at the Instrument Show at Chicago. It works this way . . ."

This special section is devoted to the Society and to its exposition. None of our readers can fail to be interested in the aims and scope of this historic undertaking. *Instruments* has no connection with the A.S.T.M. but we believe it to be the duty of *Instruments* to do all in its power in connection with this project.

The thousands of our readers who are not members of the A.S.T.M. will find in this section for their convenience the floor plan, the list of exhibitors, what they will exhibit, etc.

INSTRUMENTS' BOOTH IS FOR YOU

Inasmuch as many of the visitors to the Exposition will be interested not only in testing apparatus but in instruments of classes excluded from the Show, we have reserved booth 25 at which we will maintain a general Instrument Information Service. Engineers who become interested in the remarkable progress recently made in testing some certain property or condition, can later come to *Instruments'* booth to get a line on the means available for continuously *indicating* such a property or condition in industrial plants, for *recording* it, and for *controlling* it automatically. There will not be any commercial literature in the *Instruments'* booth. It will be furnished as a lounge and all visitors to the exhibit are cordially invited to use it as a rendez-vous for meeting their friends and otherwise to use all facilities offered.

Hours of the Exhibit

A tentative schedule of Exhibit hours follows:

June 22.	Monday	12 M. (opening)	to 9 P. M.
June 23.	Tuesday	9 A. M.	to 9 P. M.
June 24.	Wednesday	9 A. M.	to 4 P. M.
June 25.	Thursday	9 A. M.	to 9 P. M.
June 26.	Friday	9 A. M.	to 5 P. M. (closing)

Deserve Credit

The Advisory Committee on the A.S.T.M. Exhibit of Testing Apparatus and Machines is as follows: Cloyd Chapman, H. N. Van Deusen, and H. E. Smith. C. L. Warwick, Secretary-Treasurer of the Society has been in active charge of the Exhibit, assisted by R. J. Painter.

1. The "Commercial" Exhibits

FOLLOWING is an alphabetical list of exhibits where the leading instruments and apparatus on the market may be examined by visitors. We head this list "commercial" but the exhibits possess great educational value; and to the practical men engaged in actual testing work they will no doubt prove as interesting as the purely educational exhibits of A.S.T.M. Committees and great research institutions, though with a different appeal.

Booth No.

AMERICAN ASKANIA CORPORATION 32
1603 S. Michigan Ave., Chicago
Glass strain viewers; Askania Vibration Meter; Askania Minimeter.

BALDWIN SOUTHWARK CORPORATION 2-4
Paschall Station, Philadelphia
Universal Testing Machine, Oxweld Portable Tester; Huggenberger Tensometers; Whittemore Strain Gauges; Peters Electric Telemeters.

BAUSCH & LOMB OPTICAL CO. 33
635 St. Paul Street, Rochester, N. Y.
GBILSAA Metallographic outfit; Quartz Spectrograph Microscope; K Camera; DDES Microscope; GS-8 Microscope; FFSC Microscope; BKW-5 Binocular Microscope; 1813 Lamp Color Comparator; Hydrogen Ion Colorimeter and Accessories; 2414 Colorimeter Lamp.

CHRISTIAN BECKER, INC. and Associate Company THE TORSION BALANCE CO. 28
228 N. La Salle St., Chicago
Analytical Chainomatic Balances; Chemical and Laboratory Balances; Weights.

THE BROWN INSTRUMENT COMPANY 3-5
Wayne & Roberts Ave., Philadelphia
Potentiometer Pyrometers: 3-Record, 3-Point, 2-Point, Single Record 3-Position and 2-Position; Indicating Pyrometers; Single Record Recording & Controlling Millivoltmeter Pyrometer; Multiple Recording Milli- Pyrometer; Indicating and Controlling Millivoltmeter Pyrometer; Recording & Integrating Flow Meter with Planimeter; Continuous Chart Recording & Controlling Flow Meter; Brown Indicating Flow Meter; Continuous Record Liquid Level Recorder.

BURGESS-PARR COMPANY 20-22
111 W. Monroe St., Chicago
Adiabatic Calorimeter; Oxygen-Bomb Calorimeter; Peroxide Calorimeter; Illium Bomb for Sulfur Determinations; Melting-Point Apparatus, Turbidimeter; Razek-Mulder Color Analyzer; Burgess Acoustimeter.

CENTRAL SCIENTIFIC CO. 18
460 E. Ohio St., Chicago
ASTM Ball & Ring Apparatus; ASTM Distillation & Dehydration Apparatus; ASTM Elec. Oven with Rotating Shelf; Thermostatic Water Bath; Carbon Residue App.; Crank Case Dilution App.; Gas. Dis. App.; Flash Point Tester; Sulphur App.; Vacuum Ovens; Sillimanite Ceramic Wares; Vacuum Control App.; Thermoregulators; High Vacuum Pumps; Rheostats; Electric Heaters; Balances for Cement Testing.

CONSISTOMETER CORP. 9
322 S. Michigan Ave., Chicago
Stephens Mechanical Consistometer (with 6 different attachments for different tests).

THE GAERTNER SCIENTIFIC CORP. 12
1201 Wrightwood Ave., Chicago
Linear Measuring Machines; Brinell Microscopes; Laboratory Telescopes & Scales; Measuring Microscopes; Optical Levers; Sensitive Optical Gauges; Quartz & Glass Flats; Standard Scales; Cathetometers; Chronographs; Chronometers; Quartz Spectrographs; Wavelength Spectrometers; Microphotometers; Interferometers; Industrial Lab. Supports and other Scientific Instruments for testing.

THE EMIL GREINER CO. 16
55 Vandam St., New York
Petroleum Testing Apparatus; Constant Temperature Viscometer baths; Herschel Friction Apparatus; Colorimeters; Penetrometer; Improved Form. Absolute Viscosimeter (Vogel-Ossag).

J. B. HAYES, INC. 6
Urbana, Ill.
Moore Extensometer; Rotating Beam Testing Machine; Repeated Torsion Machine; Repeated Tension Machine; Reversed Bending Machine; Diffraction X-Ray Spectrograph.

HUMBOLDT MFG. CO. 34
2014 Nebraska Ave., Chicago
Humboldt Ductility Machine; Asphalt Briquette Mold No. 115; Humboldt Adhesion Machine 120; Humboldt Penetrometer 125; Do. Miniature-Portable Type 125; Asphalt Viscosimeter 140; Pitch Mold 145; Softening Point Apparatus; Flash Point Tester (Cleveland Open Cup Type); Grease Consistometer and Needle; Grease Worker; Shear Machine; Cement Briquette Molds, single and 3-gang; Cement Cube Mold 288; Cement Cylinder Molds, single 290 and 3-gang 292; Concrete Cylinder Mold 294; Cement Fineness Shaker; Cement Consistency Tester 305; Cement Set-Time

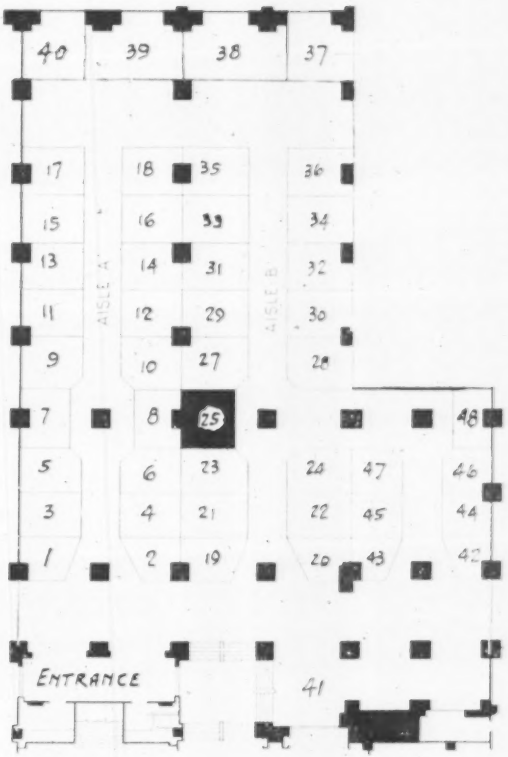
Booth No.

Tester 315; Eureka Testing Outfit for Specific Gravity and Moisture Determinations of Aggregates; Humboldt Delimeter; Measures for Unit Weight Determination of Aggregates; Flow Table for determining flowability of Mortars 329A; Slump Cone 330; U. S. Standard Sieves 392; Interchangable Screens for Field Testing 399; Triple Beam Top Scale 437.

E. LEITZ, INC. 1

6 E. 45th St., New York

Microscopes for metals, etc.; Dilatometer to record curves of heating, etc.; photomicrographic cameras, etc.; Equipment for Ultra Microscopic Investigations.



FLOOR PLAN OF THE EXHIBIT AT THE STEVENS HOTEL

Instruments' Booth is No. 25

MOREHOUSE MACHINE CO. 36

York, Pa.

Proving Instruments; Apparatus for testing the Springiness of Magnet Wire

NEWARK WIRE CLOTH CO. 24

Newark, N. J.

A.S.T.M. Testing Sieves; Wire Cloth.

PRECISION SCIENTIFIC CO. 14

1736-54 No. Springfield Ave., Chicago

Burners; Clamps and Supports; Crucibles; Extraction Apparatus; Kjeldahl Apparatus; Oil Testing Apparatus; Distilling Apparatus; Stirring Apparatus; Cement Testing Apparatus; Heaters and Hot Plates; Water Baths; Water Stills; Calorimeter, gas, hand type; Calorimeter, gas, recording type.

RIEHLE BROS. TESTING MACH. CO. 19-21

1424 North 9th St., Philadelphia

Riehl Precision Hydraulic Universal Testing Machine.

Booth No.

13

E. H. SARGENT & CO.
155 E. Superior St., Chicago

Freas Electric Ovens; Microscopes; Microbalances; Refractometers; Penetrometers; Distillation Apparatus; Balances and Weights; Water Stills; A.S.T.M. Oil Testing Equipment.

10

THE SHORE INSTRUMENT CO.
Jamaica, N. Y.

Monotron Static Constant Diameter Hardness Indicator; Scleroscope—Model C-2 vertical-scale and Model "D" dial Recording Hardness Testing Sets; Durometer and Elastometer for measuring hardness and elasticity of rubber.

36

STEEL CITY TESTING LABORATORY.
Detroit, Mich.

Krause Universal Testing Machine; Transverse Testing Machine; Standard hand-operated Machine; Type P Hardness Testing Hammer; Power-Operated Brinell Machine; Type P-2 Sheet Metal Tester; Compression Tester for Concrete Cubes.

THE PLACE—HOTEL STEVENS

THE DATE—JUNE 22-2

27-29

ALFRED SUTER representing LOSENHAUSENWERK
2 *Fifth Ave., New York* *Dusseldorf*

Hydraulic Universal Testing Machine; Charpy Impact Tester; High Temperature Testing outfit; Hand Brinell Tester; Brinell Tester and Microscope; Lathe Tool Dynamometer; Textile Testing Apparatus.

23

C. J. TAGLIABUE MFG. CO.
Brooklyn, N. Y.

A.P.I. Hydrometer; A.S.T.M. Thermometers; TAG Union Colorimeter; Saybolt Chronometer and TAG Daylight Lamp; TAG Thermostatic Viscosimeter, 2-tube, with Universal and 4-tube, Furol Tips; TAG Heppenstall Moisture Meter for wood, for grain; Saybolt Testing Lamp; Rather Burning Test Gage; TAG A.S.T.M. Reid Vapor Pressure Bomb; TAG A.S.T.M. Grease Cone & Worker; TAG Recording Thermometer; TAG A.S.T.M. Oil & Moisture-in-wax apparatus; TAG ASTM Cloud & Pour Test App.; TAG ASTM Carbon Residue App.; TAG ASTM Distillation App.; TAG ASTM Pensky Martens Tester; TAG ASTM Cleveland open cup tester; TAG Closed Tester.

17-15

TESTING MACHINES, INC., associated with H. Z. SCHNIEWIND FOREIGN PAPER MILLS, INC.
314-316 Broadway, New York

Tensile Strength testers for metals, paper, textiles, rubber, etc.; bending testers for Wires, others for tin plate, insulating materials, cardboard, linoleum, etc.; Brinell hardness testers (std. types); portable Brinell Testet; Impact Hardness Tester; Hardness tester for soft rubber; Scratch hardness tester for varnish films; wire torsion tester; Paper Testers; Folding Endurance Tester; Schopper-Dalen Bursting Strength Tester; Standard Micrometers and thickness gauges; Basis weight and other automatic scales; Freeness Tester for pulp and beater stocks; Standard tensile tester; Rapid strength and stretch tester; Expansion tester; Cardboard testers; Air permeability (porosity) tester; Ash tester; Bulking tester; Blotting Paper tester.

THE THOMPSON GRINDER COMPANY Springfield, Ohio Booth No. 8

R. R. Moore Fatigue Testing Machine.

THE W. S. TYLER COMPANY Cleveland, Ohio 11

Tyler Testing Sieve Shaker complete with sieves and Sieve Rack; No. 4 Ro-Tap Testing Machine complete with brass weights, No. 1 and 2 Splitters, Standard Field Sieves for complete testing. Wire cloth of various meshes and metals. Set of 12" diameter sieves for testing.

2. The Educational Exhibits

Everything displayed at the exposition possesses educational value. A large proportion of booths, however, are devoted to purely educational exhibits in which the fruits of recent scientific research will be shown, in some cases for the first time publicly. These exhibits are sponsored by institutions and by industrial firms. The following information includes all data obtained at the time of going to press. Note that research laboratories are assigned space in Aisle C.

We naturally mention first the A.S.T.M.'s own booth. In this booth will be shown a good many of the Society Publications, including the Book of Standards which is issued triannually; the 1930 Proceedings in two parts which is an annual publication; the A.S.T.M. Book of Tentative Standards issued annually, and several other publications such as List of Alloys, Aircraft Symposium, A-10 Tables which give detailed information regarding corrosion and heat resistant alloys and many others. This booth will also be the office of the Society representative in charge of the Exhibit, Mr. R. J. Painter.

Instruments will have on exhibit a library of scientific and industrial measurement books. The booth (25) will be furnished as a lounge, where visitors may meet one another. Richard Rimbach will be in charge and will conduct an information service on instruments of classes other than those to which the exposition is limited.

The following A.S.T.M. Committees will participate:

1. A.S.T.M. Committee A-8 on Magnetic Analysis (Chairman, R. L. Sanford; Secretary, A. V. DeForest), will have a large booth and show the following equipment.

1. Saxby's method of magnetic testing, 1869;
2. The modern magnaflux method;
3. Hughes induction balance;
4. First alternating current test, 1880;
5. Induction bridge with oscilloscope and galvanometer detectors;
6. Apparatus for chain testing, and continuous testing of razor blade steel.

2. A.S.T.M. Committee C-5 on Fire Tests of Materials and Construction (Chairman, R. P. Miller; Secretary, Fitzhugh Taylor), will show the fire test tube which they have been instrumental in devising.

This fire test tube offers a unique method of measuring the fire resistance of wood, especially to the spread of flame. A specimen of wood is suspended in a long iron tube and a gas flame is applied. An ingenious device measures the loss of weight and other measurements are also made. This apparatus has demonstrated that it is a reliable and quick method of measuring the property of wood to support combustion, and numerous successful tests have been made at the Forest Products Laboratory where it was constructed.

3. A.S.T.M. Committee D-18 on Natural Building Stone will show three pieces of apparatus which have been used in the testing of natural building stone.

The U. S. Bureau of Standards has been assigned two booth spaces. Unfortunately, we do not have a list of their apparatus as we go to press.

Westinghouse Research Laboratories are sponsoring two booths:

Plastic Flow in Metals. Dr. A. Nadai, who this year at the Annual Meeting of the Society will describe outstanding developments regarding the phenomenon of Slip in Plastic Materials, as the Edgar Marburg Lecture for the year, has evolved interesting equipment by which it is possible to see demonstrated the fundamentals of this subject. Faint traces of plastic flow can be observed by means of this apparatus and deformed surfaces of metal specimens can be photographed. Those who hear Dr. Nadai's address may visit this booth and see evidence of plastic flow.

Westinghouse Booth proper will contain three interesting pieces of testing apparatus:

1. A hydraulic testing machine suitable for tension, compression, and bending tests up to a max. load of 60 lb. The base is 16 by 16 in., 24 in. in height. This machine was developed for cross bending tests of flat springs in connection with a study of hydrogen embrittlement. It has been used also for tension tests of fine wires, cords, and even single hairs. For small loads, oil pressure is measured by a water manometer instead of the usual test gages.

2. Hydraulic testing machine for torsion tests up to a maximum torque-moment of 2 inch-pound. Its base is 14 by 14 in. and is 24 in. in height. This machine was developed for torsion tests of small wires.

3. A small cantilever Fatigue testing machine for specimens 0.050" in diameter. Base 4 by 10", height 4". This machine tests material where only a small amount is available, such as in broken-machine parts, turbine blades, etc. An investigation of the effect of the size on the endurance limit was also made with this apparatus. Total weight of this machine is ten pounds, which makes it portable equipment.

Bell Telephone Laboratories will exhibit the following testing equipment:

1. A Parallel flatness and photographic recording device for measuring the flatness of telephone transmitter diaphragms. This equipment consists of a photographic recorder in which a mechanism for translating the irregularities of the three eccentric parallel ring surfaces of the part under measurement and the parallelism of these surfaces into mechanical movements of indicating arms. Such movements are recorded on photographic tape through the media of a system of lenses and a shadow projector. This device has been used to measure the eccentricity of cams, shafts, and other machine parts.

2. Pressure Indicating Micrometer. This instrument measures the thickness of resilient or compressive sheet insulating materials such as paper, rubber, and leather under conditions of constant pressure.

3. Reversed Bend Testing Machine. This machine measure the ductility, toughness, and resistance to deformation of sheet metals.

4. Filament Wire Extensometer. This measures the load deflection rate of the very small wires such as vacuum tube filament wire. From these data curves can be plotted from which the modulus of elasticity and proportional limit of the material can be determined.

5. Compressibility Machine for Insulating Materials. This machine was designed to study the deformation under load characteristics such as hard rubber, phenol fibre, and plastics, cellulose acetate, at different temperatures. The maximum value of the applied load is 1000 pounds.

6. Fatigue Machine for Sheet Metals. This machine was designed to test simultaneously 40 specimens of sheet metal in varying thicknesses. The deflection of the reciprocating arms upon which the stress depends can be varied at will.

The Cooperative Fuel Research Steering Committee will exhibit Knock Testing Equipment which they have developed.

The Department of Public Works' Bureau of Standards, City of Los Angeles, will have in their booth the following apparatus:

1. A compressive cement compaction machine.
2. Vialog (Road roughness recorder).
3. Auto-Set (Automatic cement setting time device).
4. Bituminous mixture extractor.
5. A miniature Rattler for rock toughness.

They will also have a motion picture projector showing miscellaneous test processes. Mr. T. A. Fitch, member of A.S.T.M., is Director of this Bureau.

In addition to these Research Laboratories, the following will have displays:

1. Western Electric Research Laboratories.
2. University of Michigan, Department of Engineering Research.
3. Universal Oil Products Company.

It is expected that there will be equipment showing the gamma ray testing of thick sections of metal from radium.

Officers of The American Society for Testing Materials

President—K. G. MACKENZIE, Consulting Chemist, The Texas Co., New York City.

Vice-Presidents—F. O. CLEMENTS, Technical Director, Research Laboratories, General Motors Corp., Detroit, Mich.; CLOYD M. CHAPMAN, Consulting Engineer, 105 W. Fortieth St., New York City.

Secretary-Treasurer—C. L. WARWICK, 1315 Spruce Street, Philadelphia, Pa.

Members of Executive Committee—G. B. HAVEN, Professor of Machine Design, In Charge of Textile Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.; C. R. HOOK, President, The American Rolling Mill Co., Middletown, Ohio; F. H. JACKSON, Senior Engineer of Tests, U. S. Bureau of Public Roads, Washington, D. C.; ZAY JEFFRIES, Consulting Metallurgist, Aluminum Co. of America, Cleveland, Ohio; H. H. QUIMBY, Consulting Bridge Engineer, Philadelphia, Pa.; G. A. REINHARDT, Director of Metallurgy and Research, The Youngstown Sheet and Tube Co., Youngstown, Ohio; H. E. SMITH, Engineer of Materials, New York Central Lines, New York City; H. N. VAN DEUSEN, Materials Engineer, Bell Telephone Laboratories, Inc., New York City; G. E. WARREN, Assistant General Manager, Portland Cement Ass'n., Chicago, Ill.

Past-Presidents—H. F. MOORE, Professor of Engineering Materials, University of Illinois, Urbana, Ill.; G. W. THOMPSON, Chief Chemist, National Lead Co., Brooklyn, N. Y.; T. D. LYNCH, Consulting Metallurgical Engineer, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

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Philadelphia Claims Honor of "First Instrument Exhibit"

A friend from the Quaker City sends us the notice printed below, which is self explanatory. Evidently, the A. S. T. M. show is not the "first" one but we still believe that it is the first international or at least nation wide exhibit of instruments ever held in this country.

THE PHYSICS CLUB OF PHILADELPHIA

The last meeting of the Physics Club for 1930-31 will be held Friday evening, April 24th, 1931, at 8 o'clock in the Lecture Hall of the Randal Morgan Laboratory of Physics, University of Pennsylvania.

This meeting will be a departure from the usual single speaker subject and will consist of an exhibition of scientific instruments of specialized application in the industries of interest to science teachers as demonstrations of fundamental principals taught students and of interest to technicians and engineers as outstanding developments of instrumentation.

A brief description of the instruments will be given by the representatives of the firms participating.

During the social hour, members and their guests will adjourn to the Exhibit Rooms for further inspection of the instruments.

The following firms will exhibit:

LEEDS & NORTHRUP CO.
BROWN INSTRUMENT CO.
PRECISION THERMOMETER & INSTRUMENT CO.
HIERGESELL BROS.
RUBICON CO.
JAMES G. BIDDLE
BECK BROS.
BOEHMKE OPTICAL CO.
THWING INSTRUMENT CO.
ELECTRICAL INSTRUMENT & ENGINEERING CO.
GRAY INSTRUMENT CO.

MABEL A. PURDY Secy-Treas.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company

ELEKTRISCHE MESSMETHODEN UND MESSINSTRUMENTE. By *Prof. Dr. Siegfried Valentiner.* Vol. 82 of "Die Wissenschaft." Verlag F. Vieweg & Sohn A. G., Braunschweig, 1931. Cloth, 5½ x 8¾ inches, 152 pages. Price 12 R.M.

The author states in the preface that lack of a short manual for laboratory work for students prompted him to write this book. It is much more than that. Section I, dealing with definitions and fundamental units, is elaborate enough to make this difficult field understandable to the student. This may or may not be an advantage but the student may use it as a valuable repetitorium on account of its conciseness. The other section (II) deals with electric and magnetic measurements in a thoroughly complete manner, and avoids becoming a simple recipe book by always giving a brief theory of the respective measuring methods and description of the instrument. Of particular value are the many diagramatic sketches which do more to elucidate the subject than lengthy descriptions. Friends of the radioscience will also find with great satisfaction all measuring methods explained for determining quantities particular to this field; on the other hand, the measurement of radioactive materials and radiation is treated a little scantily (only two pages). In all, however, the little volume will fulfill its purpose quite well.—Max Hartenheim

HANDBUCH DER WISSENSCHAFTLICHEN UND ANGEWANDTEN PHOTOGRAPHIE. Band II. Die photographische Kamera und ihr Zubehoir. *Karl Pritschow.* Verlag Julius Springer, Vienna, 1931. Cloth, 7 x 10 inches, 590 pages. Price, 69 RM.

The second volume of this treatise on photography is devoted to the taking of the picture and deals with everything that is required, be it for the amateur, the commercial photographer or the artist. This volume shows the making of the camera from the beginning to the highest refinement, cameras for plates, roll-films, cut films, reflex cameras; the optical theories of lenses, fixed focus cameras, panoramic and stereoscopic cameras, cameras for [illegible] photography, all are thoroughly described and many makes are illustrated. Filters and their theory, distance meters, exposition-time finders, tripods, shutters in all their diversity, enlarging apparatus, and finally methods and materials used in the production of cameras and also their testing, nothing is overlooked, and each section has its history of development. A more complete text book can hardly be conceived.—Max Hartenheim

An Ideal Tensile Testing Machine

J. T. Nichols

THOSE directly concerned with the production of any commodity frequently become so absorbed in the detailed requirements of the job that fundamental considerations are forgotten. So it becomes desirable, from time to time, to consider what would be an ideal product and to use its description as a guide to immediate practical improvements. For this purpose it is proposed to describe briefly a tensile testing machine which might be considered to be ideal, at least from the user's view point.

First of all this machine has been carefully designed to impress a pure tension upon the specimen in exact alignment with its axis. In this respect many existing machines are painfully wanting and it must be remembered that unless this condition of correct alignment of stress prevails a tensile test is practically useless. The means by which this alignment is secured must be robust and permanent so as to withstand repeated and forcible shocks. The devices provided for gripping the specimen are carefully designed and built to assure a uniform distribution of stress throughout the cross-sectional area of the specimen. This again, is of fundamental importance and is a feature too often neglected by the builders of these machines. We must remember that the interpretation of tensile tests depends entirely upon two premises, that the stress applied is in exact alignment with the axis of the specimen, and that the stress is uniform throughout its cross-sectional area. If these two statements be not true the test is worthless.

In addition to providing for these two fundamentals this ideal machine is provided with an accurate, automatic indication of the load which is being applied. Accuracy within $\pm \frac{1}{4}\%$ is guaranteed and is attained partly by reason of the fact that its designer has not tried to make it operate over too great a range of loads. For most purposes it is a mistake to attempt to build a machine which will be required to measure accurately loads of less than 10% of its capacity. Machines which require manual balancing of the load introduce the personal equation of the operator at a vital point where it should be excluded. Therefore the ideal machine is automatically balanced regardless of whether the load is increasing or decreasing and it makes an accurate stress-strain diagram which permits the determination of yield points by the newer and more accurate methods. The drop of the beam method of determining yield points, which is generally used, is satisfactory on only a few materials and gives wholly unreliable results on many. This method of determining yield points is a continual source of worry to the operator and of inaccuracy in the tensile results. On the other hand the use of the accurate extensometers now on the market makes testing slow and tedious and is frequently impossible in routine testing. The ideal machine is provided with a device for making an accurate stress-strain diagram automatically and without serious delay in testing, thus lifting a load from the operator's shoulders and providing accurately determined yield points. This is perhaps the greatest difference between the ideal machine and existing ones.

The calibration of this machine is permanently accurate because of the correct design of its parts which are both designed and built to withstand the severe shocks incident to its use. Old fashioned knife edges are conspicuous by their absence, having been replaced, where necessary, by the immensely superior elastic knife edges which can be replaced, even if they are broken, without changing the machine's calibration.

The speed with which the specimens may be pulled is adjustable and under the control of the operator at all times. But a step beyond this provision has been taken. The speed is maintained automatically at a constant value, set by the operator, and is indicated on a dial visible to him. Controversies arising between different testing laboratories regarding tensile properties can frequently be traced to the fact that different and uncontrolled speeds of pulling the tests are used. It is an undoubted fact that tensile properties, especially yield point and elongation, are influenced by the speed at which tests are made and yet most testing machines make no attempt whatever to control this important variable or to indicate its value to the operator.

In the details of its construction and the materials of its manufacture this machine is vastly superior to those we are familiar with. All exposed metal parts are of an alloy steel which resists corrosion and maintains permanently the fine appearance it had on the test floor. Controls and dials for the use of the operator are efficiently arranged within easy reach and the specimen grips are arranged so that a test piece can be inserted in the machine with a minimum of effort. Charts for the autographic stress-strain diagrams are continuous like those now used on recording electrical meters and, being approximately 90 feet long, replacement is required only at long intervals.

This machine is also provided with valuable accessories including a convenient and accurate gage marker for putting the marks on the specimen which are required for the measurement of elongation, a convenient device for measuring elongation and reduction of area, and a specially designed slide rule for calculating stresses from the dimensions of the test piece and the loads indicated by the tensile machine. In routine testing, operators who are unfamiliar with slide rules are frequently employed. This special slide rule is circular to prevent running off the rule, and its scales are so designed as to permit determination of the stress and cross-sectional area, if desired, at a single setting. For the benefit of those unfamiliar with slide rules, its scales are long enough so that results may be obtained to three significant figures without interpolation. This results in the performance of large numbers of routine calculations with a minimum of arithmetical errors.

It may appear to some that undue stress has been laid upon the ability to make tests and calculations rapidly. A little consideration, however, will reveal the fact that small numbers of tests are practically worthless for research because of variations in the material itself which make it necessary to use average values determined from large numbers of tests. Large numbers of tests also have the immense advantage of making possible, by application of the laws of probability, a direct determination of their own reliability. In testing for the purpose of meeting specifications it is obvious that the greater the number of sample tested the better is the picture obtained of the tensile properties.

THE HANDBOOK OF INDUSTRIAL INSTRUMENTS

CHAPTER XIV

Timing and Scheduling Instruments

M. F. Béhar*

3. Time Indicators

Various classifications were discussed in Section 2, heading (a). In this section we only divide industrial time indicators into (a) elapsed time indicators—usually registering operating time and not registering idle periods—which start, stop, resume and stop automatically† and (b) signalling or other "timers" excluding however the time switches or other timers which are automatic controllers.

(a) Elapsed Time Indicators

New General Electric Time Meter—This instrument (Fig. 441) indicates the actual total operating time of any electric equipment using alternating current. Within the meter is a synchronous motor, like that used in a G. E. Telechron clock, which operates while the circuit of the equipment is closed. This motor, through suitable gearing, drives a cyclometer five-digit counter, arranged to read in either hours or minutes. The meter is supplied on a pedestal for portable use, or with a threaded connection for permanent conduit mounting. The meters are available for 110, 220 or 440 volts and for 25, 50 or 60 cycles; but no one device has more than one voltage or frequency rating.

Fig. 441

Esterline-Angus Time Counter. This is an ingenious electrical arrangement whereby minutes and tenths of total elapsed time are indicated on a direct-reading register that exposes a row of numerals like an ordinary counter. This result is obtained by placing in a series circuit the following elements: (1) a contact on the producing machine, which contact remains closed while a piece is being produced; (2) a timing contactor producing ten contacts per minute, and (3) the counter itself. By means of this disposition of elements the counter receives ten impulses a minute from the contactor but only when the machine is producing. The timing contactor is a motor-driven device which produces an electrical impulse ten times per minute. The device is driven by a 110 volt 60 cycle synchronous motor.

*Engineering Editor

†Elapsed time indicators which do NOT start and stop automatically with the machines or circuits but require manual operation (such as stop-watches and fly-back chronographs) find many uses in industry, to be sure, but the author deems it unnecessary to classify, illustrate and describe them.

The contacts proper are designed to operate ten counters. When more than ten are used, a small inexpensive relay can be installed so that one timing contactor will handle the entire installation. The contactor may be mounted on the instrument case or located on a panel with the electrical counters.

Elapsed Time Electric Clocks. Almost any of the now familiar electric clocks may be used as an elapsed time or production time (or as an idle time) indicator by means of a suitable contactor or cut-out switch. Thus, at the beginning of a work day, such a clock could be set at "12 o'clock" and at the end of the day it would indicate the hours and minutes during which the circuit was closed.

The Hasler Tel Running-Time Meter (R. W. Cramer & Co.). This instrument indicates the total operation or production time of the piece of equipment on which it is installed directly, or to which it is connected by a flexible shaft. Three types are available: (1) Dial calibrated to register up to 100 hours, and repeat; can be read directly to 3/5 of one minute, and by estimation to 1/5 minute. (2) Dial calibrated to register up to 1000 hours, and repeat; can be read directly to within six minutes, and by estimation to 2 minutes. (3) Dial calibrated to register up to 10,000 hours, and repeat; can be read directly to one hour, and by estimation to within 20 minutes. The only limitation of this instrument is that it must be driven from a rotating member of a machine, so that it does not seem to be applicable to most types of chemical processing equipment or even to machines which vibrate in operation but have no rotating parts, but apart from this limitation it appears to possess noteworthy advantages. For one thing, "it is impossible to advance or retard the registration of time, or to augment or diminish the accrued total. The elapsed time you read on the dial is absolutely the time the machine has worked." It is not affected by vibration, magnetism, gravity or temperature fluctuations and requires no winding or other manual attention. It weighs 28 ounces and measures 3½ inches in diameter. While it requires a rotating drive shaft, it indicates elapsed operating time irrespective of the speed of the machine on which it is installed, and irrespective of the direction of rotation, or variation of direction of rotation. The mechanism is manufactured at the Hasler works in Switzerland.

(b) Indicating Timers

The ordinary alarm clock is the prototype of all such instruments. Industrial models, however, represent advanced stages of evolution. In spite of the variety on the market, it does not seem necessary to devote much space here to many of these instruments. Instead, only two have been selected and only one of these is described here, the other—a combination signaling and recording instrument—being described in Section 4.

Stromberg "No. 55" (Stromberg Electric Co.). This instrument is representative of the modern industrial trend of process timer design and construction, and several features are shown on Fig. 442, and described as follows by the manufacturer:

The dial shown has a maximum length of interval of 3 minutes and 48 seconds and is graduated in two second intervals. (Dials having longer lengths of intervals and different graduations are furnished as standard to meet particular conditions.)

E is the setting hand, which is set to show the period of time of the process. In the illustration the instrument is set for a process of 1 minute and 25 seconds. (The setting hand is

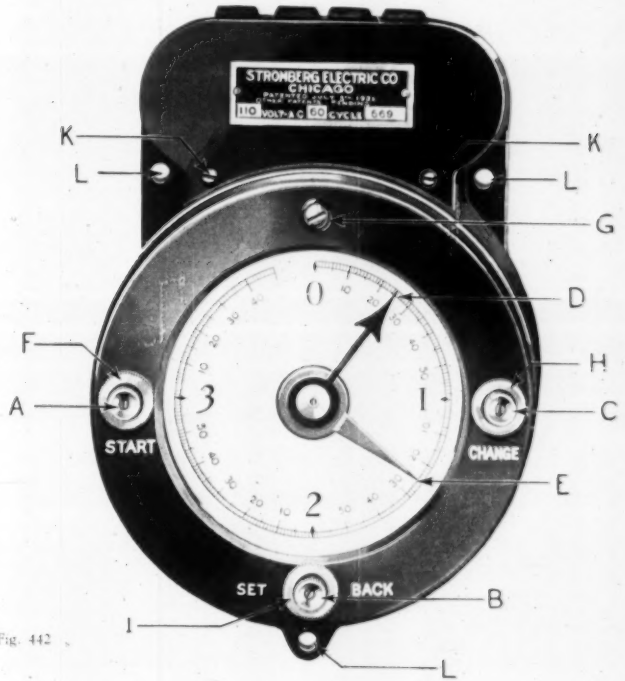


Fig. 442

enameled red.) D is the indicating hand which starts from the point at which the instrument has been set and travels to zero. In the illustration the indicating hand has started at 1 minute and 25 seconds and has traveled one minute, and shows that 25 more seconds must elapse before the process is completed. (The indicating hand is enameled black.)

C is the button for setting the instrument for any length of process desired. The pushing in and then turning of the button C sets the instrument for a new length of process. The turning of this button also causes the setting hand E to move and by observing the location of the setting hand the instrument can be quickly set for any new length of process. C button may be locked to prevent setting by an unauthorized person.

When the indicating hand reaches zero an electrical contact is made to transmit current to signals which announce the completion of the process. The signal continues to operate until the operator pushes button B which causes the indicating hand to throw back quickly to the starting point, at which the instrument is set. In the instrument illustrated the indicating hand will move back to 1 minute and 25 seconds. The indicating hand then remains stationary at the starting point, until the operator is ready to start a fresh process, at which time button A is pressed, which releases the indicating hand and causes it to immediately begin to travel toward zero, in correct relation to time.

"*Signal-Graph.*" See below under time recorders. This is a combination instrument.

4. Time Recorders

No attempt has been made to arrange the instruments described below in a technically progressive order otherwise than by placing the single-record or single-purpose recorders first, and the more elaborate instruments and the chronographs at the end of this section. (The ones at the end are not necessarily the latest, nor the first the oldest. All are modern.) The selection, through somewhat fortuitous, is fairly representative.

(a) Chart-less Recorders

The Calculagraph. The various models of this instrument print starting time, finishing time and "elapsed time" (see Section 1) on a job ticket or any other form which it is desired to employ. There being no mechanical, electrical, pneumatic or hydraulic connection between the instrument and the production machines or processing equipment, the times are *not* recorded automatically whenever an operation or process starts and stops: the cards must be inserted manually in the instrument. On the other hand, the very fact that the instrument has no physical connection with any one or any battery of pieces of production equipment makes it possible to use it "in connection with" any number of machines or men or jobs—the number being limited only by practical considerations such as walking distance. Extracts from the maker's own description follow:

At the beginning of a job or operation to be timed, a ticket having the man's name or number, and any other information desired, is issued and stamped with the Calculagraph by operating the right hand lever backward and forward. The backward motion prints the time of day and date, and the forward motion prints the two circles of figures as shown in Fig. 443. These circles of figures or elapsed time dials, as they are called, are constantly rotating, and by printing them on each man's time card *when his job is begun* a starting point is determined. When the job is finished, the time card for that job is inserted in the slot of the Calculagraph as before, and the left hand lever pulled forward. *This prints two pointers* or arrows (see Fig. 444), one in each of the two elapsed time dials. In the Calculagraph mechanism, these pointers are assembled so that they always point at zero but by printing them separately when the record is closed, they will of course have moved away *from the zero mark on the card* and will point at the figures which indicate the elapsed time. Thus it is possible for the same Calculagraph to compute and record the elapsed time for any number of records no matter in what order these records are opened and closed.

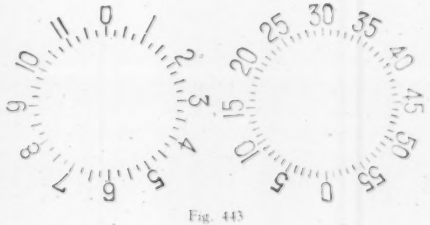


Fig. 443

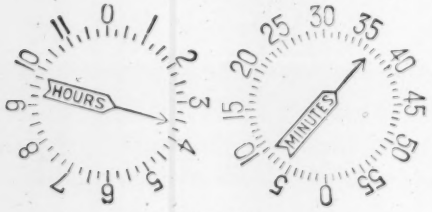


Fig. 444

Turning the hands on the clock face does not change Calculagraph Elapsed Time Records, thus preventing tampering. An attempt to make false records can be easily detected. Also the dial form of record makes other methods of falsification impossible.

Machines used for factory job time keeping purposes are equipped with a "cut-out" attachment by means of which the lunch period, time before starting, and time after quitting, as well as any other desired time, may be taken out of the records.

Calculagraphs may be said to be self-synchronizing because with records opened and closed on the same machine and the records being of elapsed time, the time of day has no effect and need not be considered.

Other Chart-less Time Recorders. Various makes of time-of-day stamps are no doubt well known to every industrial reader and it seems unnecessary to describe their mechanisms or methods of employment. They are not only "better than nothing" but often of marked usefulness in promoting efficiency—and without necessarily arousing resentment.

(b) "Operation Time" Devices for Recorders

Since recording thermometers, gages, ammeters, etc., are already provided with chart-driving clocks, many of their manufacturers list various simple and inexpensive devices which can be added to these instruments in order to produce time records of an additional processing or operating condition. Some of these devices are built into the recorder and must be ordered with it; others can be ordered subsequently and attached without much trouble. Most consist of an additional pen which travels only across the margin of the chart in order not to interfere with the regular pen or pens. Most such pens are driven mechanically, by strings, etc., or electrically by magnets. These devices are of great usefulness and it is surprising that they do not enjoy the popularity they deserve. It may be that they are not sufficiently advertised: only the C. J. Tagliabue Mfg. Co., to the author's knowledge, gives these devices a good display in its general recorder catalog.

Fig. 445

Fig. 446

Another firm that features a time attachment for its temperature and pressure recorders is the Consolidated Ashcroft Hancock Corporation. This attachment—a time punch—is different from those described in the above paragraph in that it is designed *not* to be actuated automatically, and *not* for remote operation. In other words, it must be worked manually and on the spot. The reason is that the purpose of this time punch is to record how often and when the instrument was examined: the engineer or workman who does so presses the knob of the attachment, and a hole is thereby perforated in the margin of the chart.

(c) Running and Idle Time Recorders

These instruments are physically connected to the machines, vehicles, circuits, etc., and produce records which show "on" and "off" times on round or strip charts. We first take up some of the single time record devices on the market, then those providing time records and speed records—which are most widely used on motor vehicles—and finally the more elaborate industrial time recorders.

The Ohmer-Kienzle Vibracorder is merely attached rigidly to the piece of equipment and needs no electrical or other connection. It registers running time by a broad line and idle time by a thin line, its stylus being always in contact with the chart and oscillating when the piece of equipment is vibrating. Hence it finds its readiest application on vehicles where a "medium" line shows motor running idle (see Fig. 447) but it can time any industrial apparatus that vibrates when running and does not vibrate when at rest. The chart is 5 inches in diameter and is a seven-day chart rotating once in 24 hours like that of "Tetco Tim" but instead of concentric circles the record is a spiral. A useful feature of the Vibracorder is a time punch which perforates a hole in the chart when the cover of the instrument is opened and closed. Fig. 446 shows a front view of the Vibracorder. The

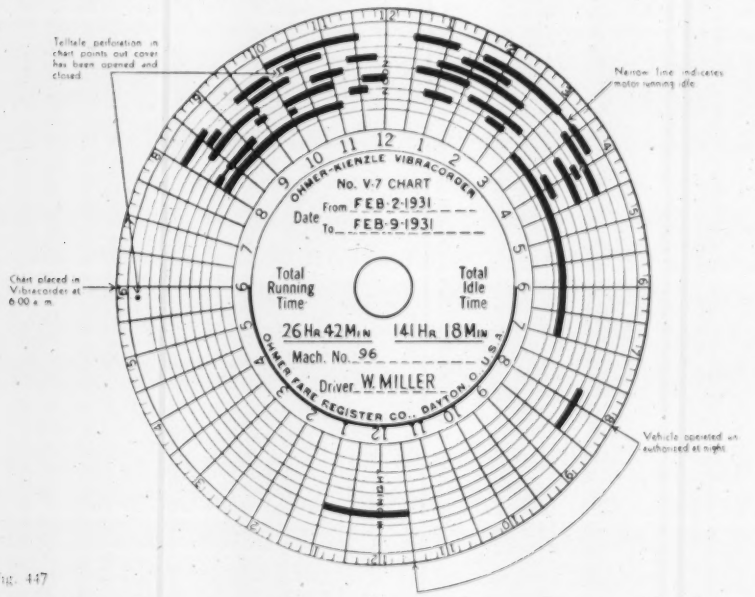

Telltale perforation in chart points out cover has been opened and closed
Narrow line indicates motor running idle
Chart placed in Vibracorder at 6:00 a. m.
Vehicle operated on authorized at night
OHMER-KIENZLE VIBRACORDER
No. V-7 CHART
From FEB-2-1931
Date
To FEB-9-1931
Total Running Time
Total Idle Time
26 HR 42 MIN
141 HR 18 MIN
Mach. No. 96
Driver W. MILLER
OHMER FARE REGISTER CO., DAYTON O. U.S.A.

Fig. 447

clock is located in the cover and not only drives the chart but serves as a regular timepiece. The semicircle below the hands is a red-and-white telltale disk which shows when the clock is running.

The "Servis" Recorder (Service Recorder Co.) is also of the vibrator type and consists of a hinged casting with an outward-opening cover, a clock mechanism which rotates a paper dial and a winding disk that also serves as a platform for the chart itself. A lock secures the cover and prevents access to the mechanism by unauthorized employes. When in operation, a needle or stylus in the upper half of the casting is actuated by a pendulum which marks the chart with a broad line while the vehicle or machine is moving, and with a fine line when the equipment is at rest. The charts used are $4\frac{1}{4}$ in. in diameter and have 24 circumferential divisions, one for each hour of the day. These divisions are further subdivided to indicate 10-minute periods. The central portion of the chart provides space for the date, vehicle or machine number, and other data. The surface of these charts is covered with paraffin which is traced off by the stylus as it travels over the dial.

The Autograph Recorder (U. S. Recording Instruments Corp.). This instrument is designed for vehicles only. It produces records on 24-hour round charts, the running and idle time record appearing only on the outer edge while the main area of the chart is used for recording mileage.

The Ohmer Recordograf (Ohmer Fare Register Co.). This instrument records on a paper tape with rectangular coördinates, time divisions running lengthwise. A record line parallel to the edges of the tape thus shows idle time, while "sawteeth" across the tape show running periods. Speed can also be measured by the inclination of the oblique portions of the record. The tape length is equivalent to 36 hours.

The Pittsburgh Truck Recorder (Pittsburgh Taximeter Co.). This instrument produces a record on a 7-inch 24-hour chart. The record is distinctive in that it is punched through the chart, appearing as a line of perforations. As many as three charts can be given. A triplicate chart record provides one copy for the garage, one for the district office and one for the main office. Altering the records so produced is practically impossible.

"Some of the facts that can be read from the chart record are as follows: (1) Time and duration of stops. (2) Time and duration of trips. (3) Total operating time. (4) Total idle time. (5) Total actual running time. (6) Time truck is taken out without permission. (7) Indication that trips have been run as per schedule. (8) To determine schedules. (9) Highest speed: miles per hour. (10) Average speed: miles per hour. (11) Mileage used without permission. (12) Total miles traveled. The instrument itself also indicates to the driver the accurate vehicle speed and the correct time of day."

The Hasler-Tel Recorder (R. W. Cramer & Co.) is designed to give a more complete performance-record than that of any of the instruments described above. The record is made on a paper tape, a part of which is shown in the rectangular opening at the top of the instrument. It can be installed on any vehicle having a speedometer driveshaft, and furnishes a permanent record of operating data, such as: time and duration of runs and of stops; total operating time, whether the vehicle is moving or standing and when; vehicle speeds attained during every second of operation; location of stops on a mileage basis; trip mileage, total mileage and an indication to the driver of accurate vehicle speeds and the correct time of day.

We now leave off the field of vehicle performance time recorders and return to industrial plant models, taking up several makes in alphabetical order.

The Bristol Company makes both round-chart and strip-chart operation-time recorders electrically operated, with either spring or electric clocks. The round-chart sizes are either eight inches or twelve inches; the strip-chart is six inches wide. Fig. 448 shows the strip-chart recorder equipped with twenty pen arms. The numerals 1 to 20 are printed at intervals along the chart to identify the records which, since they appear in parallel form, afford a ready means of comparison.

The Electric Tachometer Corporation "Tetco Tim" Recorder is an electrically operated instrument which records on and off periods of motors, lighting or heating circuits or of any manually or automatically operated circuit. "The recorder is automatic in its operation and changes at the end of each revolution of the chart so that it will record a new circle of operations. It is not necessary to replace the chart at any predetermined time. Failure to remove the chart has no effect and the chart remains intact until removed. The chart is wax-coated so that no ink is used and the recorder can be handled in any position without damage. The recorder can be locked

and it cannot record on the chart until it is connected to the circuit and current or voltage applied. The weekly record made by this instrument enables a day by day comparison of operating periods showing the operations occurring at the same time each day. It also permits a picture of the full

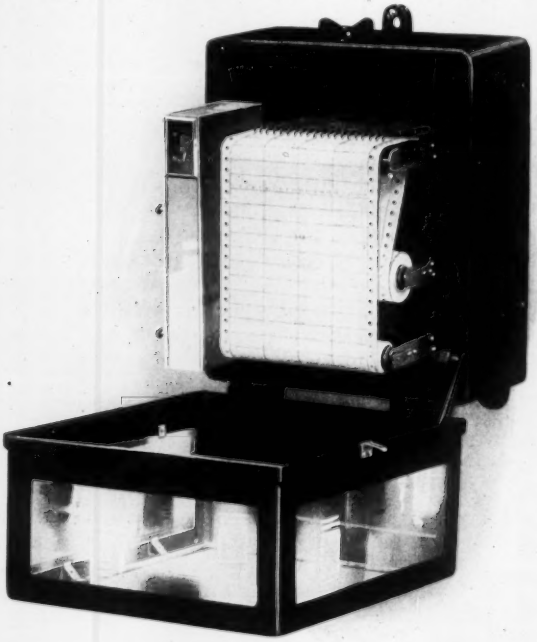


Fig. 448

week's operation on the one chart, for operating periods such as those of refrigerator motors, oil burners, coal blowers, etc., a seven-day chart is sufficient to show periods of operation. For special applications, charts making a complete revolution in 2 or 3 hours can be furnished. Two types of recorders are available:

Fig. 449

The series type is for use on refrigerator motors, etc., where it is only necessary to plug the appliance in the recorder outlet and plug the leads from the recorder in the floor outlet. This simplifies connections and does not require getting inside of the appliance for proper connections. This type of recorder is, however, limited in the current carrying capacity to 20 amperes and for higher capacities the potential type should be used.

The potential type is similar to a voltmeter in its operation. It is connected across the circuit or motor terminals so that as soon as the circuit has potential due to automatic or manual operation

the recorder operates. With no current flowing through the recorder the writing stylus is held away from the chart. As soon as current flows through the recorder or potential applied the writing stylus is placed in contact with the chart and traces a line as long as the circuit is on. As soon as the circuit is off the stylus lifts away from the chart and shows the off period as an open space in the record circle.

Fig. 449 shows the series or plug-in type of recorder. The potential type is similar except that lead wires are used to connect the recorder across the line. The potential recorder can be furnished for various voltages AC or DC and can be used with potential transformers for higher voltages. A 5 ampere current coil enables operation with a current transformer for high capacities.

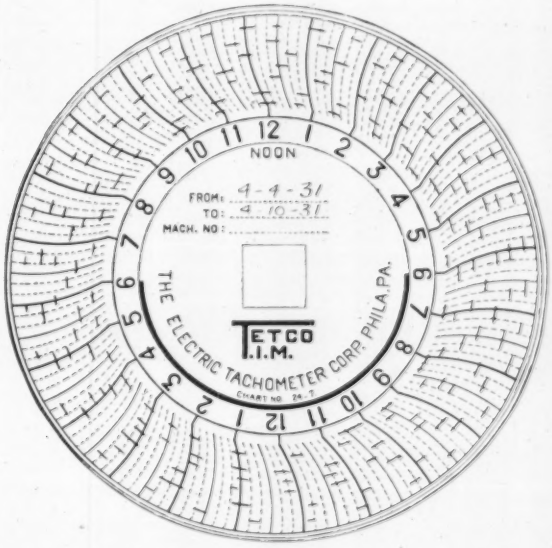


Fig. 450

The chart, Fig. 450, shows seven days' operation of a refrigerator motor. The on periods are shown by the marks and the off periods by open spaces. Each complete circle represents one day and each time division covers a 10-minute period. The chart is $4\frac{3}{4}$ inches in diameter.

The Esterline-Angus Company's time recorders are all of the strip-chart form. See Figs. 451 and 452. In addition to the time records, there are available other features of industrial interest:

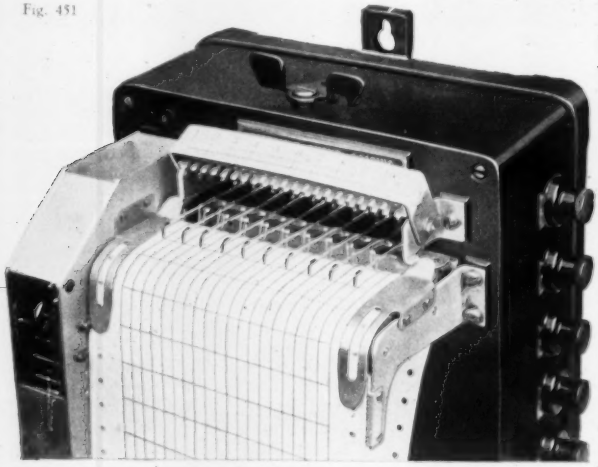
The Esterline-Angus time recorder makes a record of the rate at which operations take place and shows the productive and idle time. In addition to this record the *number of operations* can be totalized. In order to obtain this total, an electrically operated counter is furnished which, when connected in the same circuit with the pen of the recorder, registers the total number of impulses actuating the pen. One counter is used with each pen and they may be grouped in a central place.

Where it is necessary to have, in addition to a record of the production and a total of the operations, the *total actual working time*, this can be obtained through the use of a timing contactor and an electrical counter as described above in Section 3 under heading (a).

The time recorder is composed of three essential parts, viz., the containing case, the chart-driving mechanism and the writing elements.

The *cases* are of three general forms, portable, wall and switchboard. The portable type has a carrying handle, and weighs complete about twenty pounds. The wall cases are provided with lugs so that they can be fastened to a flat surface. Switchboard cases have studs which extend through the panel for mounting the instrument. Time recorder meter elements can also be furnished in *twin type cases*, made only in switchboard and wall types, which accommodate two complete meter elements so that two time recorder units up to twenty pens each can be placed, or a time recorder unit and any other standard meter element, such as a voltmeter, ammeter or wattmeter can be used in combination.

Fig. 451



Two types of *chart drive* can be furnished, namely spring-wound clocks and synchronous motor operated clocks. On clocks which give hourly chart speeds only, the purchaser has the choice of ¾, 1½, 3, 6 or 12 inches per hour. When specified, the clock can be fitted with a minute speed attachment which will give the above chart speeds per hour and per minute.

The *recording mechanism* consists of a series of writing pens, each operated by a small electromagnet. Standard recording elements having five, ten or twenty pens can be placed in a single meter. Twin type cases will accommodate as many as forty pens.

Instruments can be furnished to operate on direct or alternating current, at voltages ranging from 6 volts to 750 volts. The operation of the pens is exceedingly rapid, each pen being capable of recording distinctly as many as ten operations per second.

Charts are six inches wide and ninety feet long. They can be furnished printed for chart speeds of either ¾, 1½, 3, 6 or 12 inches per hour.

Electrically operated *counters* can be furnished for operation on voltages between 6 and 220 volts, A. C. or D. C. The energy required to operate the counter is approximately 12 watts for the D. C. and 25 watts for the A. C. type. The mechanism is sufficiently fast to register accurately operations occurring as rapidly as ten per second. Standard counters have five figure wheels, four black and one red. Special counters may be furnished with more figure wheels if desired.

The Foxboro Company makes electric time recorders in the round form with any number of pens up to nine in the 10-inch size and twelve in the 12-inch size; and in the tape-chart type which can be equipped with up to six pens, the chart traveling at a speed of 1, 3, or 6 inches per hour.

Production Meter Service Corporation. *The Signal-graph* is a meter made especially for platen presses. It is used for recording the length of time of plastic cures and also for signaling the operator when the predetermined time of cure is reached. This meter has an eight-day chart graduated in hours and minutes; six inches representing one hour. The meter is so arranged that the recorded end of the chart can be torn off and unrecorded part left in the meter. The instrument is actuated by a Telechron motor movement. A crank arm is attached to the moving part of the press through a connecting rod so arranged that when the ram of the press is moved to the closed position the pen arm is moved to the right of the chart and the predetermined time mechanism is set in motion through the closing of a clutch.

The graduations of the minute wheel and the chart graduations being of the same length and in turn driven by the same gears, the time indicated on the chart and that shown on the

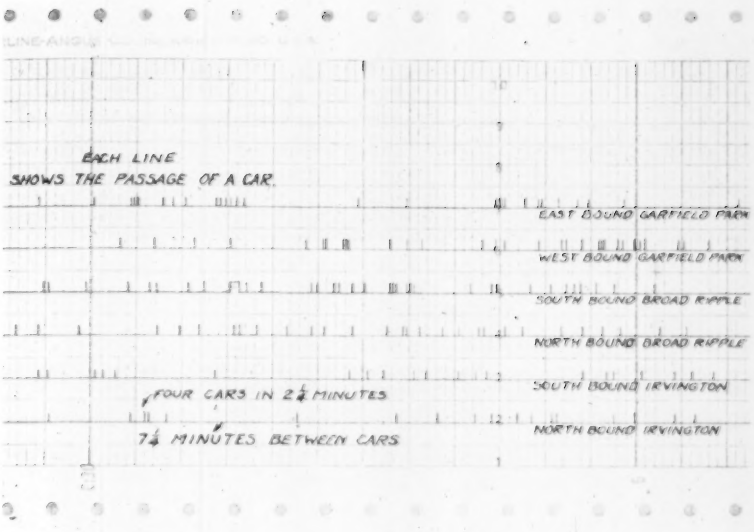


Fig. 452. Section of a record from a time recorder used to register the headway and passage of cars on six surface tracks. Each short line on the record shows the passage of a car on the particular track, and the distance between these lines is an indication of the time and the distance between cars at the hours shown on the margin of the record. (*The Esterline-Angus Co.*)

dial is identical and the length of time the press is closed is shown on the dial and recorded on the chart. When the press is opened the crank arm is moved in the reverse direction, the clutch is released, the predetermined time dial is re-set automatically to zero or starting position, the pen arm is moved to the left of the chart and records the time elapsed until the press is again closed. Records are readable to less than quarter minutes.

A notched wheel, also graduated in minutes, is moved to the position required to obtain the proper curing time or predetermined time wanted at which the signal is to be given to the operator. This wheel is locked in this position and remains fixed until it is changed by releasing the locking mechanism and moved forward or backward by hand to a new time setting. The range is from zero to fifty-five minutes, obtainable in steps of quarter minutes. Another adjustment allows still finer settings, it being possible to adjust to seconds by turning a micrometer screw to the proper position. This adjustment can be made with the meter in operation. When the press is closed, the predetermined time dial is set in motion by the closing of the clutch and when the predetermined time is reached, an electric contact is made which closes the signal circuit operating a bell or light or any other device for visual or audible signal to the operator. If the operator does not obey this signal, the chart will record the length of overcure and the signal will continue to show for several minutes or as long as the press is allowed to remain closed, thus calling attention to the fact that the operator is not "on the job."

Production Meter Service Corporation. The Production Meter. This instrument performs the same functions as the "Signal-graph" but combines a number of units serving a battery of presses. This instrument is located in an executive office and is electrically connected to the presses. Various chart widths are used, depending on the number of units which number is practically unlimited in instruments made to order.

C. J. Tagliabue Manufacturing Company. This firm employs its standard round chart recorder cases for electrically operated time recorders with one or two pens, in the 10-inch size. It also makes a mechanical type time-operation recorder which is really a motion recorder (see Chapter XVI).

(d) Chronographs

From the industrial point of view, and as compared with the time recorders described above, these instruments are *micro*-chronographs. Most of the commercial models are designed for the laboratory rather than for the industrial plant, and it has apparently come about that no matter how such an instrument for recording very small time periods may be built, if it is used continuously in connection with production it is called a time recorder; whereas if the same instrument is only used for testing it is called a chronograph. Some so-called "fly-back chronographs" are forms of stop-watches which do not produce records and as J. E. Haswell remarks in his classic treatise "Horology," the name is then a misnomer. Oscillographs may be employed as micro-chronographs.

Among the methods of obtaining extremely short time intervals for chronographic purposes are (1) to take second signals from a clock, (2) to impress an alternating current of known frequency upon an oscillograph vibrator and obtain the alternating wave form on a film, thus giving 120 parts in the case of a 60-cycle wave; (3) using a tuning form driven by a vacuum tube or otherwise; (4) using two vacuum tube oscillators, the frequency of which is made independent of impressed voltages and of slight changes in circuit constants by means of either crystal or magnetostriction control—the reason for using two being that the frequency of one is too high for usual purposes so that two are used, with slightly different frequencies, and their beat frequency is used for the measuring interval; (5) a constant-speed wheel with notches on its periphery together with a light source and a moving film, is discussed by G. R. Town in *The Review of Scientific Instruments* for August, 1930 (reprints furnished by the Leeds & Northrup Co.) This Leeds & Northrup set-up is not a commercial apparatus but deserves mention as being probably the only one that can measure any time interval from 20 microseconds to 10 seconds or longer to a precision of 20 microseconds, and which furnishes a continuous record making it possible to locate any event within the time interval to the same precision.

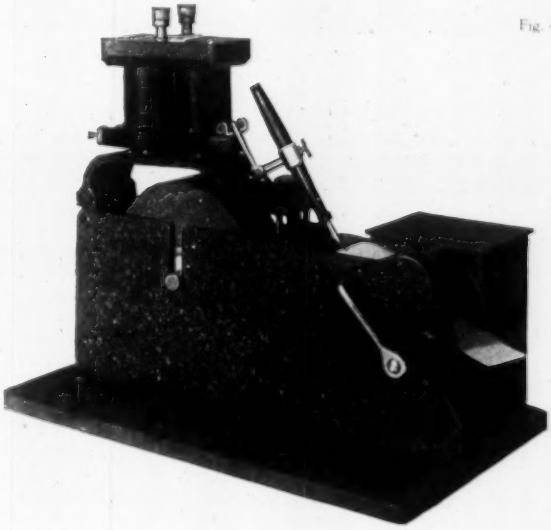
Commercial oscillographs are available which produce fairly wide films on which, in addition to the time divisions, a number of separate records may be made. An oscillograph may be considered as the "clock" of the recorder of a condition or of several conditions other than duration. In other words, a recording voltmeter, say, consists of a voltmeter plus a "slow" or clock-driven chart on which time lines are previously printed; and an oscillograph voltmeter is a voltmeter plus a device having a fast-traveling film *originally* blank on which time intervals of the order of thousandths of seconds are recorded together with the voltage record. Thus, the essential difference between those instruments termed "recorders" and the chronographs and oscillographs, is that the latter produce together with records of the measured magnitudes *parallel* records of time intervals which are not used as "records" but in lieu of the time lines of ordinary record charts. Various oscillographs are illustrated and referred to in other chapters under the objects of measurement to which they are primarily applied—time interval being the reference and not the measured magnitude itself. Chronographs, on the other hand, are designed primarily for the measurement of durations. This is one distinction between oscillographs and chronographs.

The "parallel record" referred to above is not an absolute necessity. It is a convenience; an instrument which makes a chart travel at a constant and known speed does not need to produce a wave form or other such time interval scale, because an ordinary inch or millimeter rule can be used.

Such instruments are on the market. They do *not* "graph" the "chrono" but are nevertheless called "chronographs" for want of a more appropriate name. At any rate, they are widely useful.

Chronograph "A-390." This is a single-pen instrument of the type just described, made by the Gaertner Scientific Corporation. The paper tape is 28 mm wide (a little over an inch) and 120 mm long. A Telechron motor causes it to travel at the rate of 60 mm per minute so that a millimeter rule can be used to measure off seconds. The electromagnetic recording pen operates on 3 to 4 volts. Other models are made with two and with three recording pens. Any of these three instruments may be furnished with a more powerful Telechron motor for higher speeds of paper travel, up to 20 mm per second. Fig. 453 shows the most recent model.

Fig. 453



Printing Chronograph. Fig. 454 shows the printing chronograph of the Gaertner Scientific Corporation which produces, in addition to the record of whatever may be measured, a parallel continuous time scale consisting of three rows of *numerals*, which form of scale is quite a convenience. The numerals in the first row are the minutes; those in the middle row are the seconds and those in the third row are hundredths of seconds, but the type wheel which produces this row has, adjacent to the type, a graduated scale with 200 raised lines, each being equivalent to 0.005 seconds. In determining intervals of events with this instrument, one need only read off directly when starting from zero; or one need only subtract one set of figures from the other, using the 0.005-sec. graduations for closer measurements, and in no case is it necessary to measure with a rule. Other features are described in the following extracts from the manufacturer's description:

The principal components of the chronograph are a powerful driving clock, the printing and controlling mechanism, and the necessary operating relays, together with accessories, such as switches, contact keys, etc. The clock with printing mechanism and controlling device is mounted on a heavy bakelite plate which forms the top of a case in which the relays, fuse blocks, and other accessories are mounted. Access to the case can be obtained through a removable panel.

A shaft extending from the driving clock, running at a speed of one revolution per second, carries a ratchet wheel with 100 teeth, in which engages a pawl attached to a shaft coaxial with the clock shaft on which is mounted the 0.01 seconds type wheel. The pawl is disengaged from the ratchet wheel through the operation of a small electromagnet (control magnet) without interfering with the speed of the driving clock. The method of control is as follows: The clock is adjusted to run sufficiently fast to gain about one second in six minutes. The control magnet, which is connected through a relay in the chronograph with the regulator clock or chronometer, receives by means of a special contact device, an impulse only when the chronograph driving clock has gained .01 seconds; then the pawl is disengaged

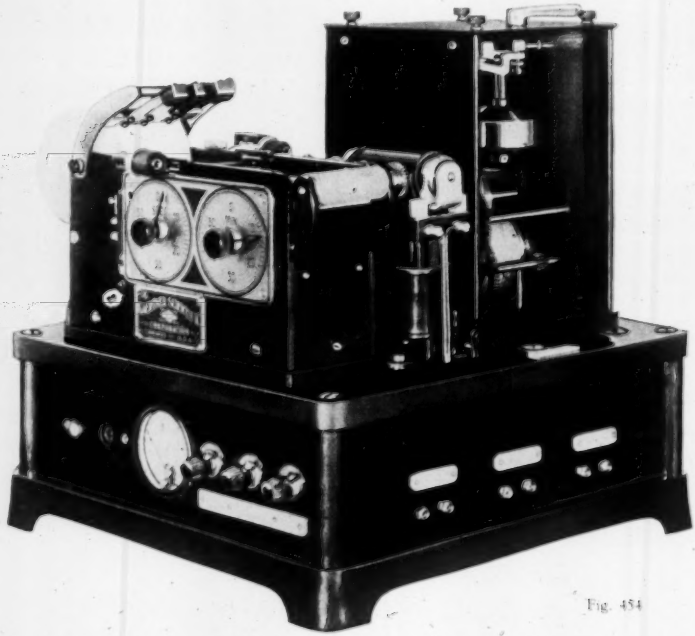


Fig. 454

and the 1/100 seconds type wheel retarded for .01 seconds. In order to have the control operate with a regulator clock or chronometer which does not make a contact every second, a device is provided which allows an impulse to the control magnet only every fourth second.

The type wheels are independently mounted on coaxial shafts running in ball bearings, and are actuated through the driving clock. The wheel for printing hundredths of seconds, has a continuous rotation as given by the pawl engaging in the 100-tooth ratchet wheel on the clock shaft. The type wheel for printing seconds is actuated through a cam attached to the first wheel. The type wheel for printing minutes is also actuated through a cam attached to the second wheel shaft. The exact printing positions of the second and minute wheels are shown on two clock dials. . . . The paper is of good white grade, 50mm by about 50 meters long. The prints are made through a silk ink ribbon, which is shifted automatically after every print. The prints are immediately visible and accessible for notation.

(e) Pyrometric Cones

Fairchild and Hoover investigated pyrometric cones thoroughly and their findings (obtainable from the American Ceramic Society) show that a set of cones as usually employed does not register—by the comparative deformation of the three or four numbers—the maximum temperature to which it was subjected, but furnishes what we might call an integrated record of the *duration* of exposure and of the *rate* of heating, as well as of the furnace atmosphere conditions. Such data can be read from the appearance of cones only by those that are skilled in their use, but a list of time recorders

for industrial processes would (it is believed) be incomplete without mention of pyrometric cones.

5. Single Duty Controllers

This section deals with time switches, timers, etc. designed neither for multiple-control schedule nor for "condition-curve" or "gradual" control. Although such plain timing controllers can be described as modified alarm clocks, those for industrial service bear only a generic resemblance to alarm clocks. Here, for example, is a résumé of the specifications of the time switch shown in Fig. 461.

. . . The time movement is a self-winding clock with oversize precision-cut gears, polished steel pinions; heavy cold rolled hard brass clock-plates, paired by a process insuring perfect alignment and finish of the bearings; 11-jewel lever escapement (this entire unit being interchangeable in all Sauter self-winding clocks). Bréguet hairspring. Invar metal balance wheel (unaffected by fluctuations in temperature); 4-day mainspring, rewound automatically by electric motor twice every 24 hours (to restore clock to exactly its "fully-wound" position); positive and simple mechanical release precluding all danger of over-winding . . . When desired this clock can be furnished with the Sunday-cut-out; automatically causing the time switch to suspend its functions every seventh day . . . The toggle switch control contact is operated by 24-hour dial; the contact being used only to close the electrical winding circuit, the opening of this 20-watt circuit being accomplished from position-control wiping-contacts on rotary main-switch-shaft. (Hence no possiblity of reversal of "on" and "off" operations). . . . The main switch is motor operated . . . double break, quick acting, laminated brush contacts with substantial arcing tips. The entire main switch operates in a batch of circuit-breaker oil, to maintain long contact-life under these heavy loads. These contacts are guaranteed for constant load at rated capacity (per pole) plus 25% overload. The electric motor is of the series type, 115/230 volt, operating on any standard frequency or on direct current without adjustment, it being "Universal." Voltage drops of as much as 20% are without effect upon dependability . . .

Only a few of the many makes on the market can or need be described. To engineers and other industrial readers the illustrations here shown are largely self-descriptive so that the text can be cut down. One instrument is a time control feature for non-time controllers; all others are the usual uncombined or self-contained instruments. Note that while this section covers only what we may call single-duty controllers, there are included instruments capable of controlling a plurality of circuits. Only recent developments are illustrated. While classifications according to many different methods are possible, we shall merely divide all instruments into (a) "timers" or controllers independent of time of day, and (b) clock time controllers or astronomical time switches.

(a) Controllers Independent of Time-of-day—"Timers"

The General Electric Company's Type TSA timers contain a contact making device driven by a Warren synchronous motor. The applications, therefore, must be on AC circuits at any standard frequency. The total time cycle, consisting of one "on" period and one "off" is *repeated* continuously and its duration is fixed in each case at the factory but in some forms the relative "on" duration can be varied by the user. One form (TSA-1) is shown in Fig. 455. Other available modifications.

(1) A single-pole switch with a one-way contact. The relative "on" and "off" time is non-adjustable. (2) A single-pole switch with a one-way contact. The relative "on" and "off" time is adjustable. The range of adjustment permits the contacts to be closed for any duration of time up to the maximum of 60 per cent of the total time cycle. (3) A single-pole switch, with a two-way contact. It is used for closing a second circuit instead of shifting to the usual "off" position. The relative "on" and "off" time is non-adjustable. (4) A single-pole switch with a two-way contact. It is adjustable as to the relative "on" time.

A new General Electric timer is shown in Fig. 456 which has to be self-explanatory, details not being available at the time of writing (June 1931).

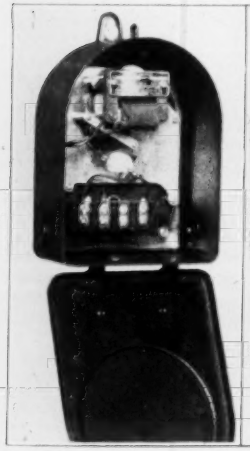


Fig. 455

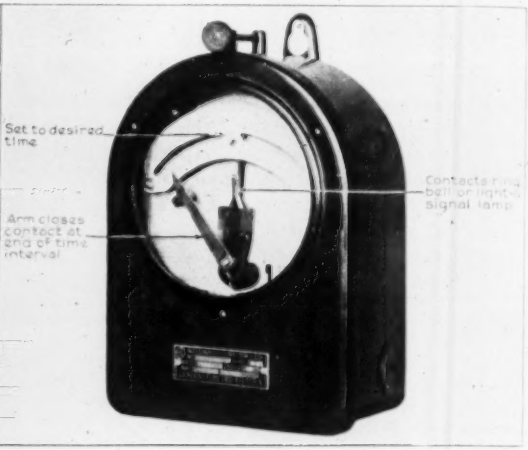


Fig. 456

On electric appliances carrying up to 6 amperes at 110 volt AC or DC the 4-inch diameter timer, Fig. 457 (Walser Automtaic Timer Co.) designed for shutting off the current at the end of the period for which it is set, is easily applied, being furnished with cord, plug and socket. The clock movement is built especially for its purpose. It does not require winding and does not run when the pointer is at rest.

Fig. 458 shows another Walser timer, similar in most respects to the foregoing but with a base enabling it to be located on a shelf or table.

Fig. 457

Fig. 458

Similar in appearance to the signaling time *indicator* of the same make shown in Fig. 442 is the Stromberg Electric Company's Automatic Contact Repeater. Fig. 459 shows the wiring layout for a "No. 57" Automatic Contact Repeating Instrument controlling the starting of a motor at pre

determined intervals. Each time the instrument makes a contact the relay contact is closed, and the magnetic switch in the motor circuit is energized, thereby starting the motor. When the apparatus driven by the motor has moved a certain distance, contact A is momentarily opened; the magnetic switch is de-energized and the power circuit to the motor is broken, thus stopping the motor.

Note that this particular instrument's cycle does *not* consist of one "on" period and one "off" period: the instrument makes a contact the duration of which is 1 second or 2 seconds. There are many applications where one of the time elements in a cycle must be "flexible"—that is, determined by a processing condition other than time. In this case it is the distance over which the conveyor has traveled; on other applications the contact "A" might be actuated when a desired pressure or temperature has been reached.

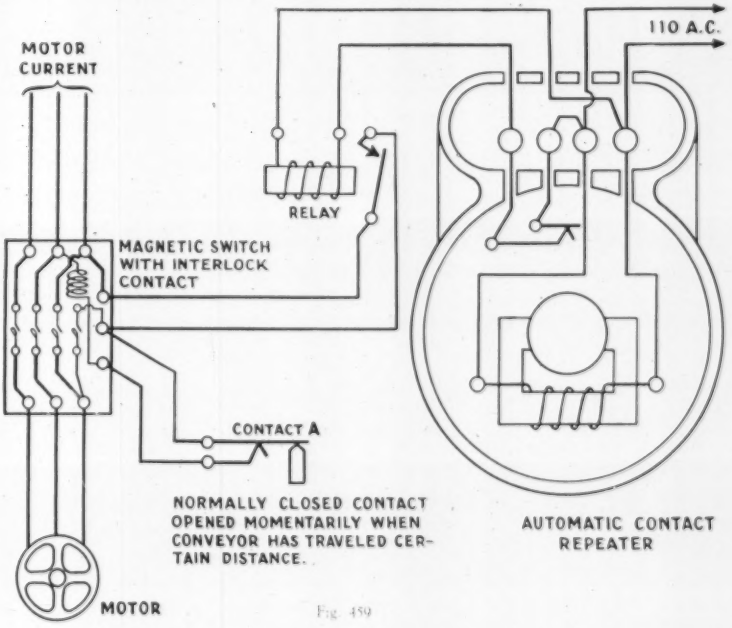


Fig. 459

An adjustable time-limit mechanism which can be incorporated in a standard temperature, pressure or flow recorder-controller is shown in Fig. 460. In the upper part of the photograph there will be recognized the mechanism of a standard Foxboro temperature recorder-controller, to which the Telechron clock in the center and the pilot valve parts 1, 2 and 6 also belong. The other numbered parts are those of the Foxboro Elapsed Time Control Feature (which also includes a signal lamp not shown in the photograph). The photograph thus shows a triple combination instrument, consisting of a recording thermometer, a temperature controller and a process-time controller. This is a 1931 development and the brief preliminary description follows:

A time index arm is driven in the same direction as the chart. It is set to the desired elapsed time point and when the time has expired and the index reaches zero an auxiliary air valve is tripped which shuts down the controller. In addition to the time scale the instrument is equipped with a mercury switch and signal lamp through which the operator is informed that the operation is concluded.

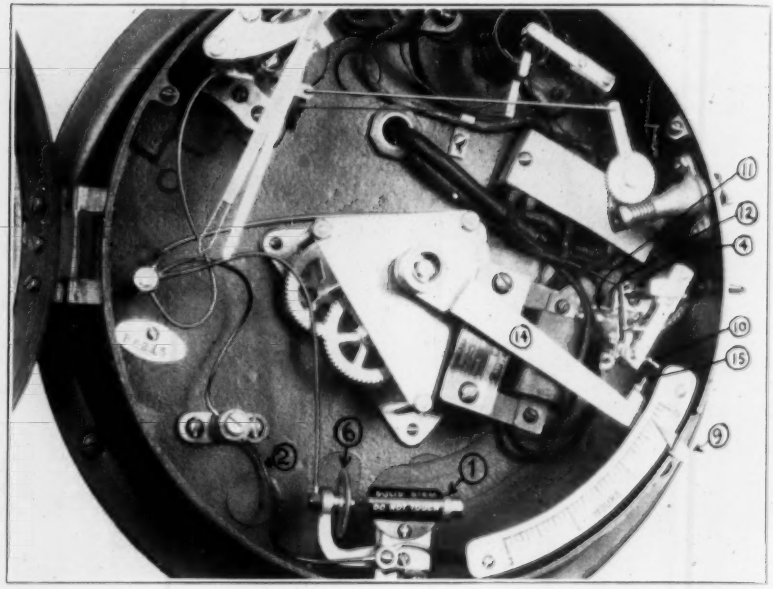


Fig. 460

The operating principle is shown in Fig. 460. The temperature or pressure control nozzle and nozzle 4 connect to the same source of air supply, therefore if index 9 is at zero, the adjustable screw 15 is in contact with arm 10 and flapper 12 uncovers nozzle 4 and makes the controller inoperative because diaphragm 6 is contracted and air is cut off the diaphragm motor and the controlled valve is closed. At the same time the mercury switch 11 is tilted, closing the circuit and lighting the signal lamp.

To start operation. Set the control point as on a regular Recorder-Controller. Move index 9 to desired time setting. When 9 is moved from zero, flapper 12 will cover nozzle 4 and as long as the temperature or pressure is below the control point diaphragm 6 will be expanded and air pressure will open the controlled valve until the control temperature or pressure is reached.

As the clock is revolving, it drives time index arm 9 counter-clockwise. When zero is reached, adjusting screw 15 comes in contact with lever 10, moving it and lever 12, which uncovers nozzle 4 and allows the system to be vented to atmosphere which contracts diaphragm 6 and cuts off air from the controlled valve and in turn shuts down the process, and as long as nozzle 4 is uncovered the controller cannot operate.

(b) Time-of-day or 24-hour Switches

Two Sauter time switches (R. W. Cramer & Co.) are shown in Figs. 461 and 462. The specifications of the former were given at the start of this section as typical of modern construction. The latter is also made in various types and for various 24-hour cycles, but differs principally in the switch unit which is employed: it is a quick-acting toggle operated brush-type switch unit with arcing tips, and cannot reverse the operating program. This switch has a wiping contact feature and is securely locked in its closed position. It is a double-pole switch which by means of a simple jumper arrangement on the terminal block can be covnerted into a single-pole switch of 25 ampere capacity on 115-230 volts. The standard dial is designed to control either one or two off-peak periods in twenty-four hours. The arms can be conveniently set for any program, are held in place by friction and can be shifted along the periphery of the dial opposite any time

mark. If more operations per day are required additional arms can be supplied. The program once set is revealed to the inspector at a glance.

The Jewel time switches (Time Switch Sales & Service) control from one to three electric circuits: turning a single circuit "on" at a set program time, later turning it "off" at a set program time; the program being variable as to time setting. An electric time switch controlling two circuits may turn both circuits "on" at one time and later, turn No. 1 circuit "off," and still

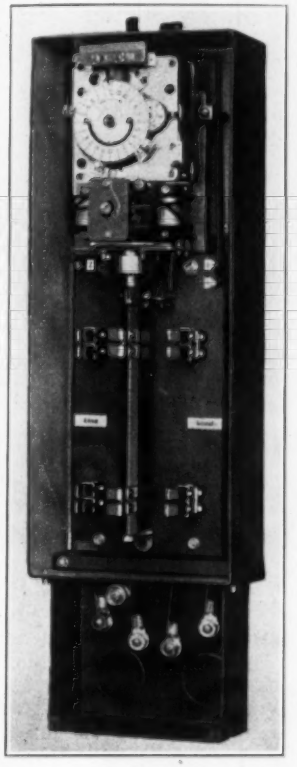


Fig. 461

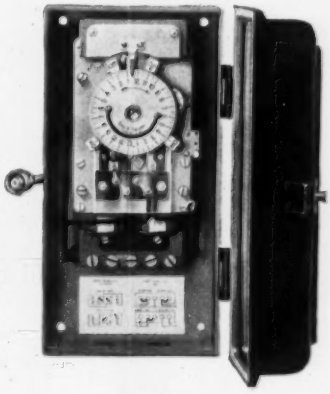


Fig. 462

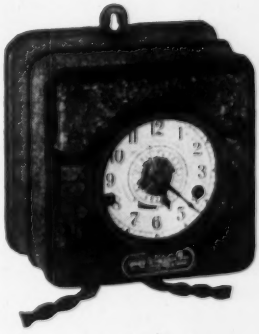


Fig. 463

later, turn the other circuit "off." Or it may be arranged to turn No. 1 circuit "on" and later No. 2 circuit "on" and still later both circuits be simultaneously switched "off." There are other two-circuits switching combinations to be obtained. These electric time switches in the single circuit types may operate three times "on" and three times "off" in twenty-four hours, and the two circuit types may make two complete operations in twenty-four hours. The No. 2 Jewel time switch is shown in Fig. 463. It has a two-compartment case, the clock movement being enclosed in the front half and the switch in the rear half.

"When the clock requires attention, such as cleaning, oiling, polishing balance staff pivots, etc., by removing two screws the front half is removed without disturbing the switch, its wires or connections. No electrician is required. The switch can then be operated by hand while the clock is being repaired, or as is the case with large users who carry a few spare front halves, a new front half can be immediately substituted for the one removed, giving immediate resumption of control."

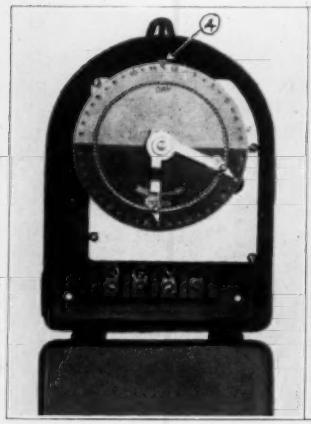


Fig. 464

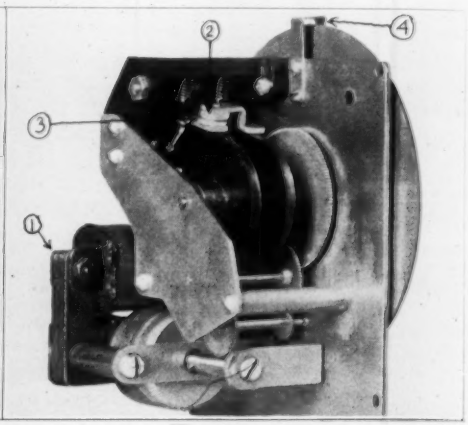


Fig. 465

The mechanism of a new General Electric time switch is shown in Figs. 464 and 465. (1) Warren synchronous motor. (2) Single-pole contactor switch having silver contacts mounted on brushes which bear on the control cams. (3) Non-flexible solid brass brushes which also act as a ratchet device permitting dial to be turned only in proper direction. (4) Time pointer projecting over top edge of dial. The time of operation is determined by the setting of two hands marked "on" and "off" which may be adjusted in steps of 15 minutes. Several 24-hour time cycles are available. One form is equipped with an additional contact providing single-pole double-throw operation, suited to the control of circuits where one must go "on" at the time another goes "off."

6. Sequence or Program Controllers

Some of the single-duty time controllers described in the preceding section come close to deserving inclusion among the program controllers described in this one. There is no well-defined boundary. We can start with an instrument which is generally classified among time switches—the "Master Control" designed by the Stat-Amatic Instrument & Appliance Co. for heating installations. Extracts from the maker's description:

The duty of this Master control is to automatically shift, at predetermined hours each one of the thermostats from the day to the night temperature level, and vice versa, each day during the week. However, in factories, office buildings, schools and like buildings, it usually is desired to hold the night, or lower, temperature over the week-end. This is very easily done, by simply equipping the clock with the Program Dial (Fig. 468). By means of this dial, it is possible to obtain almost any sort of program or schedule desired. Simply set the fingers on the program dial to cover the particular period when it is desired to maintain the lower temperature, and it will be taken care of automatically. In a factory, for example, one of the fingers on the Program Dial would be set, let us say, for 12 o'clock Saturday noon. The other finger would be set for some time after midnight Sunday. This means that the temperature would be shifted to the night, or low level, at 12 o'clock Saturday noon, and would remain at this level until a definite hour—say 6 A. M.—Monday morning.

The Plain Dial of Stat-Amatic (Fig. 467) rotates with the movement of the motor-wound clock, and makes one revolution every 24 hours. On each dial are index fingers which may be set at any hour of the day or night. If only a simple shifting from "day" to "night" and "night" to "day" temperature levels is wanted, two fingers are used. While the plain dial normally has two fingers, it may be supplied with four, if four changes are wanted. As an example, in a home from which the occupants are absent at business during the day, the

changes might occur at 6 A. M., 8 A. M., 5 P. M., and 10-30 P. M. The "day" temperature then is reached at 6 A. M., and swung to the "night" or lower temperature level at 8 A. M., back to day temperature at 5 P. M., and reduced to the night temperature at 10:30 P. M., or any desired hour.

The Program Dial (Fig. 468) is used to automatically hold the night, or lower, temperature level over the week-end without any manual attention. This dial is geared to the regular day dial and revolves *once a week*. It is equipped with two regular fingers, for "spotting out" the week-end operation as where the temperature is held at the "night" level from Friday afternoon to Monday morning. On this dial may also be used two extra fingers that may be placed in position to hold the "night" or lower temperature level over a mid-week holiday. These pins are then removed the next morning.

Fig. 466

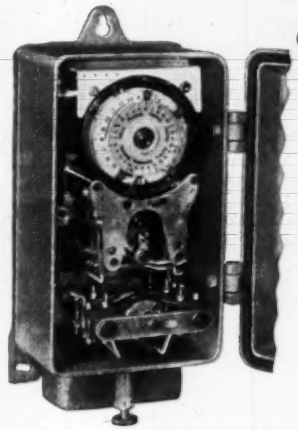


Fig. 467

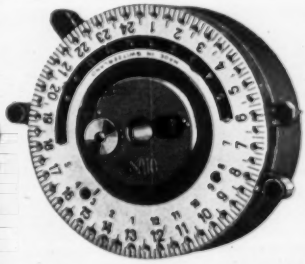


Fig. 468

The same company also specializes in time switches for street lighting installations. These instruments embody astronomic program dials whereby on and off either coincide exactly with twilight and dawn, or to other desired schedules:

"These dials determine automatically the time of lighting up and extinguishing electric lamps, street lighting circuits, etc., according to the variable length of the day throughout the year. . The dials turn one revolution per twenty-four hours . . . The helical gear makes one revolution per year. The helical wheel is connected by means of a friction plate with a small year disk . . . The cursors, actuated by the rotation of the year disk execute a reciprocating movement that moves two fingers and forward and backward along the periphery of the day dial . . . *Combination 1*—lamps lighted half of the night (evening lighting) . . . *Combination 2*—lamps lighted morning and evening . . . The other two fingers may be further adjusted so that the lamps may be automatically extinguished at say, 11:30 p. m. and lighted again at 5:00 a. m. In summer, if no morning lighting is desired, simply removed screws J and K . . . If, for some reason, "on" and "off" is desired to differ from the astronomic setting, simply slacken the nuts M and L and move the fingers G and K to the time when lighting up and extinguishing at that period of the year is desired. Then tighten nuts M and L."

"Time Cycle Contactors" is the designation adopted by the Automatic Temperature Control Company for its scheduling or program controllers—and it is accurately descriptive. Extracts from the announcements:

A few of the time cycle contactors developed by this Company may be broadly classified under two general groups, viz:

1. Cycle Repeating Contactors, designed to periodically repeat the cycle so long as the line switch is closed.

2. Cycle Stop Contactors, designed to start from a push switch, run the time cycle set and stop until the starting switch is again actuated.

Fig. 469 shows a Cycle Stop type contactor designed to handle three contacts per cycle in desired sequence. Timing and power for operation are obtained from a small synchronous motor, geared to desired time of cycle. Change gears permit altering time of cycle. One cam is pinned to the cam shaft, but the others are adjustable in relation to each other within the time of the cycle. Provision is made for shortening or lengthening the time of contact per cycle, and where necessary contacts can be provided of a type to quickly make and also quickly break their circuits. Progress of the cycle is indicated on a graduated dial. The number of

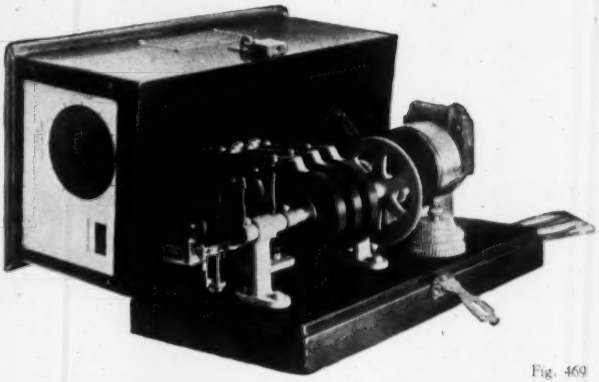


Fig. 469

operations in a given time may be readily noted as a totalizing counter is tripped each cycle. Units of this type have been built with eleven contact discs and with a cycle of 96 hours, while others have been built with a cycle of only a few seconds.

Fig. 470 shows a Cycle Stop type contactor which does not require change gears to alter the time of cycle, this change being made by means of an adjusting knob outside the case. The zero adjusting screw permits accurately setting the lower contact while the adjusting knob is used to set the upper contact for any desired elapsed time within the dial range of the unit.

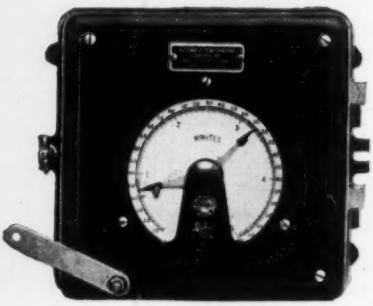


Fig. 470

Motive power and timing are obtained from a small double field synchronous motor, which moves the elapsed time contact arm clock-wise, or counter-clockwise, depending on which of its field coils are energized. This unit is built in both the Cycle Stop and the Cycle Repeating types. The extension lever at lower left hand corner is designed for operation of the reversing switch. This lever is normally held in a raised position by means of a spring, this throwing the motor line switch to "off" position. Placing the work in position for treatment mechanically pulls down the lever arm and throws the motor line switch to "on" position, thus energizing one winding of the motor, so that elapsed time contact arm starting from zero, travels clockwise for the time cycle set, upon completion of which contact is made to operate signal, or where desired, a motor operated controller. Where motor controller is used it can be arranged to automatically remove the work at the end of the cycle and in so doing the lever arm is pulled up by the spring, thus throwing the motor line switch to "off" position. When the next load of work is placed in position, the lever arm is again pulled down, throwing the line switch to "on" position, but this time energizing the other winding of the motor, so that the elapsed time arm travels counter-clockwise for the same time period, making contact at the zero position of the scale and repeating the signal or the automatic removal of the work.

The table below gives standard full scale dial ranges for this type unit, and the value per scale division.

Full scale dial range, minutes	1	2	5	10	15	20	30	40	60	120
Scale division, seconds	1	1	1	2	3	4	6	8	12	30

It is possible to set the high contact arm for any desired elapsed time within full scale range of the dial and this setting can be made *to a scale division or closer*.

Fig. 471 shows a timing contactor of the Cycle Stop type which was designed for a tunnel kiln manufacturer to gradually advance loaded cars of work through a kiln by governing the speed of a hydraulic ram under 3000 pounds pressure. Due to the possiblity of "wire drawing" the valve parts at this pressure it was not desirable to throttle the water to the ram in order to take 3½ hours for full ram stroke of 91 inches, hence it was decided to operate a two

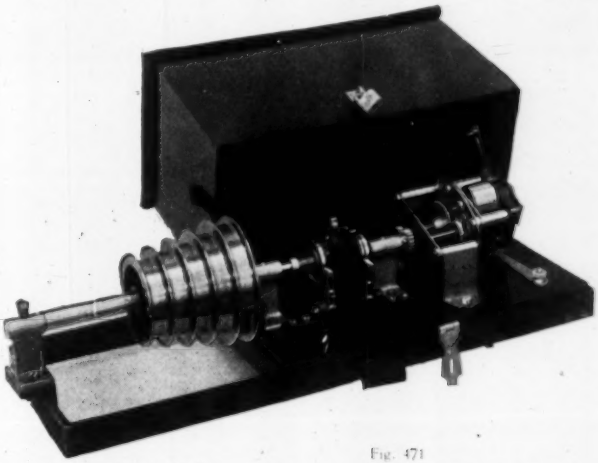


Fig. 471

position motor valve in by-pass line around the ram, this valve to be opened and closed by means of contacts carried by the timing unit. The shaft at right end is driven by a small synchronous motor geared for desired R. P. M. and carries opening and closing contacts. The shaft at left end carries the common contact and is rotated at speed the ram is travelling by means of a cord attached to the ram and passed over a cone of the step cone pulley, the pulley cone being selected according to the speed desired. In this instance the different cones reduced the ram speed in 15 minute steps from a maximum of 3½ hours. Arrangements were made that the water supply to the ram could be adjusted so that when valve in by-pass was closed the ram traveled slightly faster than desired and when open, slightly slower than desired. With the ram traveling faster than desired, the common contact on the step cone pulley shaft overtook contact on the motor driven shaft, and actuated the controller to open valve in the by-pass line tending to slow down the ram speed. This permitted the motor driven shaft to operate faster than the step cone pulley shaft, so that the opposite contact was shortly made, thus closing valve in the by-pass line, and in this way keeping the ram advancing at the desired speed. On small units satisfactory operation was obtained and less equipment required by directly operating the motor driven pump from these contacts, thus eliminating the motor control valve in by-pass lines.

The Monitor Work Cycle Timer (Monitor Controller Co.), Fig. 472, is a multi-circuit sequencing controller the most important characteristic of which "is that it can be reset instantly at the starting point at any time during, or after, the completion of a cycle" according to the maker's description, from which other extracts follow:

. . . The current-carrying switches in a given timer unit are all electrically connected on the pivoted side. Each individual switch consists of a rotable disk carrying an adjustable contact point and a post fixed on the panel and connected directly to the circuit to be controllled. There are as many of these little switches as there are circuits in the sequence. The rotable disks are mounted loosely on a sleeve which is carried on a revolving hollow shaft. Each such disk is between two rotating disks that are keyed to the shaft. These rotating disks are equipped with carbon blocks that bear lightly against the switch disks. The rotating hollow shaft is driven by a constant-speed electric motor. Through its center extends a clutch rod that can be moved by the action of a powerful magnet. When the magnet is excited, the clutch rod is pulled to the right, and all the disks are pressed together, and pressure starting with the outside disk and passing through the whole line, so that there is exactly the same pressure between all disks. Then the switches rotate, being driven through friction by the

driving disks. Rotation of each switch continues until it closes on its stationary contact post. From that time on, it simply slips between its driving disks. When the magnet is released, the pressure is removed from the disks and the reset weights cause all the switch disks to drop back to the normal rest position, ready to start again.

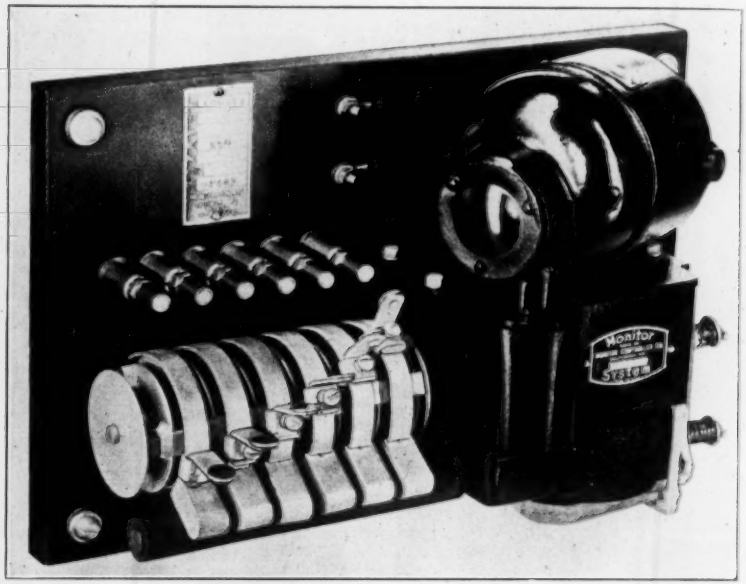


Fig. 472

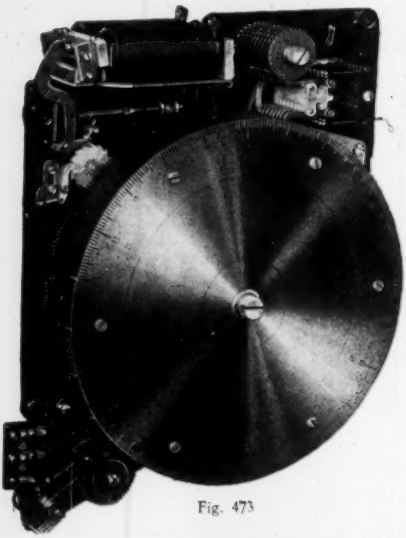


Fig. 473

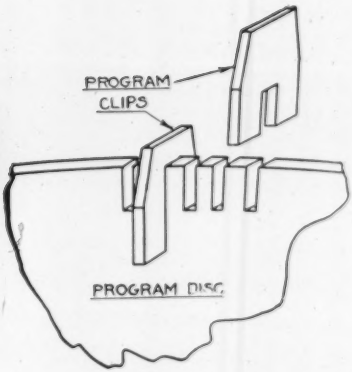


Fig. 474

The International Metal Disk Program Machine (International Time Recording Co.), Figs. 473 and 474, is most widely used in connection with the maker's well-known school and factory time control systems but is

applicable also to industrial purposes. The illustrations are largely self-explanatory. Additional data:

Schedules can be easily and quickly changed by even an inexperienced person, as often as desired, by simple shifting the position of the clips on the program disks. A heavy disk type calendar drum is arranged to silence the signals nights, Sundays, etc. The schedule on this calendar drum is set up individually for each signal circuit for a period of a week. Different schedules may be set up for different days of the week. The schedule on any circuit may be set to be automatically silenced any morning, afternoon or evening of the week. The calendar drum shifts every six hours.

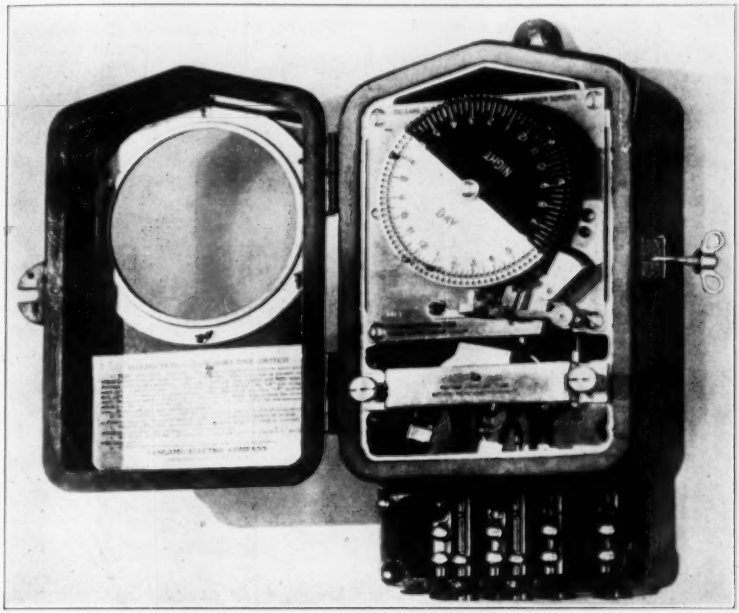


Fig. 475

Instead of clips, pins are employed for making up programs with the Sangamo timer (Sangamo Electric Co.) which has a rotating dial with two rows of holes near its edge. There are 96 holes on the 24-hour dial shown in Fig. 475, corresponding to 15-minute intervals. The timer embodies a mercury switch.

Where not only accurate timing of the various steps of a process, but also adjustable variations in the timing are necessary, and where moreover it is required to carry considerable current, the sequence controller must be of a size suited to the job. Such a controller is shown in Fig. 476, courteously contributed by *The Iron Age*, in the April 23, 1931 issue of which appeared an article by P. B. Harwood of Cutler-Hammer, Inc., the manufacturers of the controller, from which the following is abstracted:

The device was designed for timing the periods of a heat-treating process. The process was divided into three periods, and it was necessary to time each of these periods in sequence automatically. The time had to be adjustable in intervals of 1 sec., from 1 sec. to 5 min. for each part of the process. At the time when the photograph was taken only two of the timing devices were installed. The blank panel at the upper right will be occupied by a panel duplicating that immediately below it and an additional cylinder will be added to the upper left-hand panel.

A small synchronous motor was used to drive a shaft through a gear reduction. From this main shaft which ran continuously at a constant speed, smaller shafts were driven at right angles through bevel gearing. A timing cylinder was arranged so that it could be connected to the small shaft by means of a clutch. When connected to the small shaft the timing cylinder made one revolution in 30 sec. The clutch consisted of a gear which was engaged by means of a solenoid and disengaged by gravity. The timing cylinder had several sets of contacts used for functional purposes and in particular one set which made a contact at the end of each revolution. This set of contacts was used to energize the coil of a ratchet-operated pilot switch. This pilot switch, therefore, moved one notch for each revolution of the timing cylinder, or in other words, one notch for each ½ min. The ratchet-operated switch closed

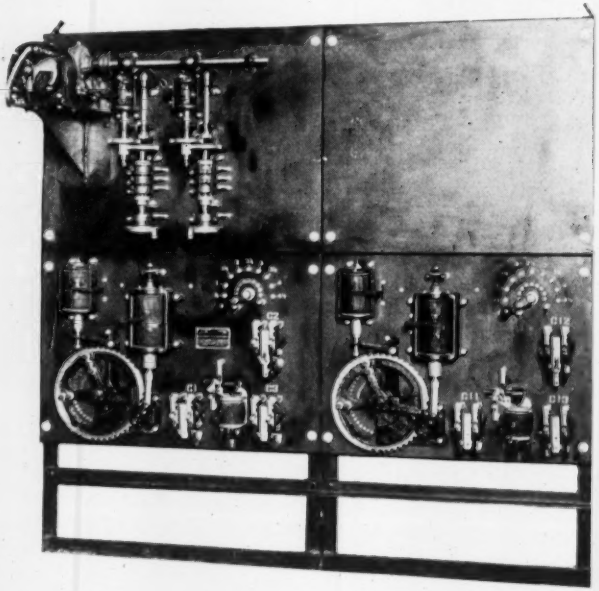


Fig. 476

a different pair of contacts on each position and by means of a manually operated selector switch it was possible to choose the desired set of contacts or, in other words, to choose the number of half-minutes required. In addition to the contacts which operated the ratchet switch the timing cylinder had an adjustable pair of contacts which could be set to close a circuit in any number of seconds from one to 30 after the timing cylinder had started to move. This pair of contacts was connected in series with the contacts of the ratchet switch so that, in order to obtain a circuit for the signaling device, it was necessary for the ratchet switch to be in the proper position according to the number of half-minutes selected and for the timing cylinder to be in the proper position according to the number of additional seconds selected. A small lever may be seen at the bottom of the timing cylinder. This was used for selecting the number of seconds required.

When the two pieces of apparatus had both reached the desired positions, in other words, when the selected length of time had elapsed, a circuit was made for a timing relay which closed immediately and operated the signal, which might be a light or an alarm bell. The pilot device and the timing cylinder immediately returned to the "off" position, but the signal continued in operation for a length of time determined by the setting of the time relay. No particular accuracy, of course, was required for the duration of the signal.

At the same instant that the signal was energized the clutch for the second timing mechanism was also energized and that cylinder started to move, thus timing the second period of the process. When the second period had been completed in the same manner as above outlined for the first period, then the third timing cylinder was started. When the third period of the process had been completed, the first cylinder was again energized.

Fig. 478 shows a portion of a Cutler-Hammer sequencing system for controlling a Cottrell precipitator. The elements of one of the ten individual timers can be seen, as well as parts of elements of adjacent timers. A pilot

motor (not shown) rotates a master timing drum at one revolution per hour (changeable at will by gear change). The master drum makes circuit for one after another of a number of the individual timers, each of which consists of a pilot motor driving, through a gear reduction, a cam shaft operating switches which control the electric circuits.

Fig. 477 shows a Cutler-Hammer motor-driven timing device, used for reversing the direction of gas flow through a coke oven every half hour or every 20 minutes as desired. The timing clock starts the operation by providing a circuit for a magnetic relay that starts the pilot motor which, through a gear reduction, drives the cam cylinder shown at the right of the panel. This makes one-half revolution for a complete operation of the ovens, in which cycle it shuts off the gas, reverses the dampers and valves and then turns on the gas again. The motors used to operate the various valves and dampers are each stopped on their own limit switches and the pilot motor is stopped after one-half revolution of the cylinder by means of a

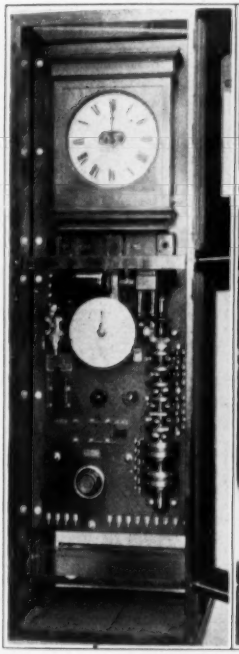


Fig. 477

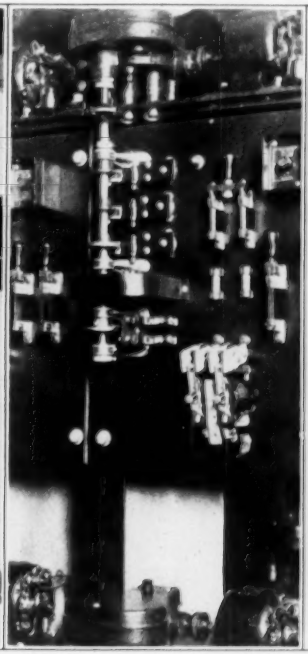


Fig. 478

Fig. 479

contact on the cylinder. When another set period has elapsed, a second contact in the clock makes circuit, which rotates the timing cylinder through the second half of its revolution and again causes motors to go through the proper cycle to reverse the valves. A double-throw knife switch permits the selection of either one of two sets of timing contacts, which may be for half-hour cycles or for 20-minute cycles. An adjustable resistance for the pilot motor is provided whereby the rotation period of the timing cylinder may be varied.

Fig. 479 shows a Cutler-Hammer inductive time limit contactor used as a *time lag relay*. The closing coil is located at the top of the magnet structure and the hold-out coil at the bottom. Less than two volts are required on the hold-out coil to prevent the contactor from closing when 230 volts are applied to the closing coil. Both coils may be connected in series across the line and the contactor will then be locked open. To close the contactor the hold-out coil is short-circuited, after which approximately two second elapse before the contactor closes. This period, required for the flux to die in the hold-out coil and magnetic circuit, may be adjusted by means of a movable nut in the hold-out coil magnetic circuit, which varies the air gap of the circuit.

It must not be inferred from the preponderance of electrically-operated controllers which have been illustrated and described up to this point, that electrical operation is universally preferable. The fact is, of course, that electrical instruments are the most conveniently built and the most numerous on the market, but air-operated controllers have their advantages, especially when time control must be combined with control of temperature, pressure, or flow. Air-operated timers are made by the principal manufacturers of temperature and pressure controllers and as we shall see in Section 8, "condition-curve" or "gradual" time control is usually effected with the aid of compressed air as the source of power. Air-operated sequence controllers (without the gradual control feature) deserve to be compared with the electrically-operated types when a sequencing installation is considered. The most recent developments in this line at the time of writing (June, 1931) are those of the Bristol Company. Extracts from the technical announcement:

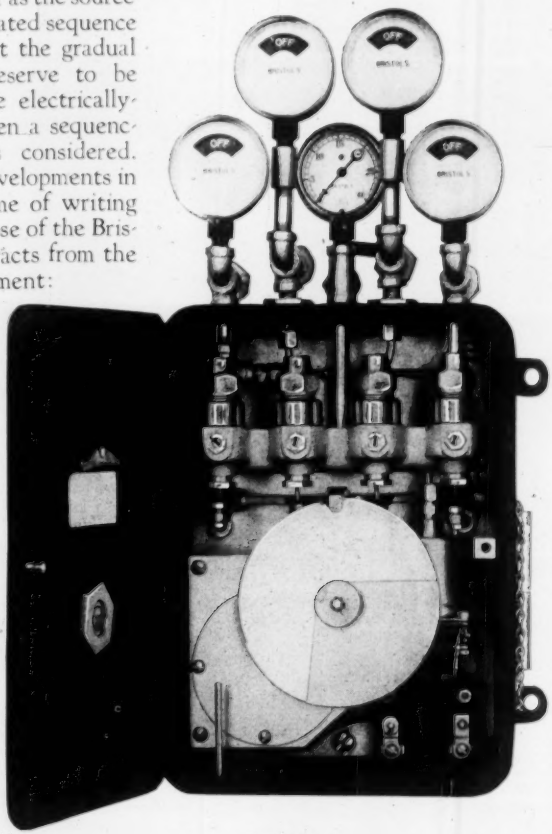


Fig. 480

In the automatic control of process cycles the maximum of simplicity at a minimum of cost may generally be obtained by the use of diaphragm-operated valves actuated by a pneumatic cycle controller. A very large proportion of controlled processes are such that the sequence of the several events which terminate the cycle is the reverse of their order at the beginning of the cycle. Where this condition holds, the operations may be controlled by a single-cam instrument, in which a number of pilot valves are actuated in turn by a motor-driven cam. This cam may be made adjustable within certain limits; and speeds are determined by change-gearing between the synchronous motor and the cam-shaft. The starting and stopping of the motor are usually governed by a pressure-operated switch within the case of the instrument. A single-cam controller is shown in Fig. 480.

Where utmost flexibility is required, and the different events in the cycle overlap by varying degrees, rendering control by a single cam impracticable, there is available the type of instrument shown in Fig. 481. Here several individual cams are mounted on a common shaft, and each is adjustable through a wide range, both as regards the duration of its influence in the cycle and its position in the sequence of events. The pneumatic features of this instrument are identical with those of the single-cam controller; but, as in the instrument illustrated, two pressure switches may be furnished, where it is desired to associate the starting and the stopping of the motor with different events in the cycle.

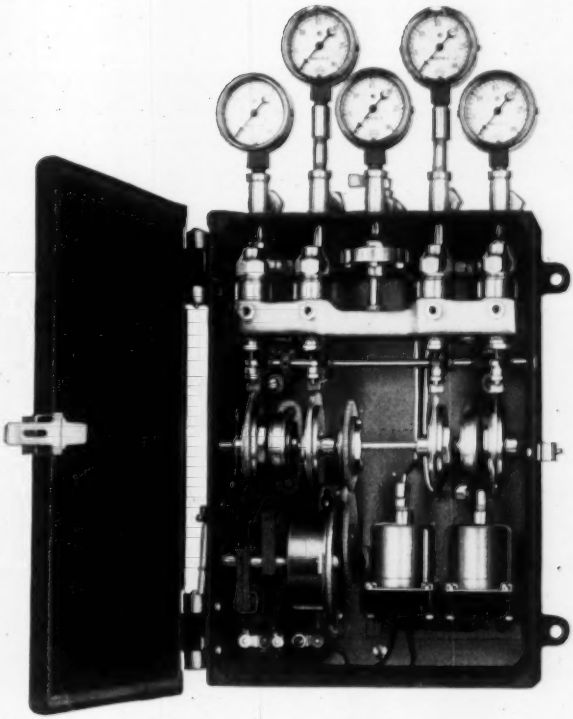


Fig. 481

Fig. 482 shows another air-operated sequencing controller recently developed (late 1930) by the Taylor Instrument Companies, designed for controlling the duration and sequence of operations actuated by steam, water, gas, electricity, or compressed air. Its operation is independent of temperature or pressure in the apparatus being controlled, although it can be arranged to operate in conjunction with such conditions.

The types of applications controllable with the various designs of this new instrument are as follows:

"The Fixed-Schedule-Cam Type 'Tyme-Cycle' Regulator finds application where the process is continuous; that is, where certain functions are to be performed periodically in a given order for an indefinite time. Also for processes where a certain number of operations must be performed in a given order and within a given period, at the end of which the succeeding duplicate cycle must be started manually, or automatically from the functioning of other apparatus. This form of operation is possible because at the end of the cycle, when the cam stops, the cam follower is in the proper position for starting the following cycle.

"The Adjustable-Cam Manual-Reset Type 'Tyme-Cycle' Regulator is used on applications where it is convenient to reset the cam manually. On processes where the final holding period on the cam must be adjustable, applications of this nature require an adjustable type of cam, which means that at the end of each cycle the cam follower will not necessarily be in the correct position for starting the succeeding cycle. To start the following cycle therefore, the cam must be revolved to the correct starting point. On this instrument an extrenal adjusting knob can be furnished for this purpose. Where it is desirable to accomplish this automatically the adjustable-cam automatic-reset type regulator should be used.

"The Adjustable-Cam Automatic-Reset Type 'Tyme Cycle' Regulator is used on applications where it is desirable to vary the duration of any of the operations which are a part of the complete processing cycle, as described in the two preceding paragraphs, but where the cam must be reset automatically to the starting position of the next cycle, within a fraction of a minute."

The mechanism (see Fig. 482) comprises a Warren Telechron motor 16 and clock 17, the cam 5, the cam follower 8, the tappet bar 10, adjustable tappets 12, and air valves A, B, C and D. The number of valves supplied with each instrument depends on the requirements of the application. The number of air gages corresponds to the number of valves used. The air supply may be anywhere from 15 to 40 pounds, depending on the device operated.

Each air valve is actuated by an adjustable tappet 12, which is raised and lowered by the movement of tappet bar 10, in which the adjustable tappets are fastened. The individual tappets can be adjusted (see 12) to make contact with the individual air valves at any desired

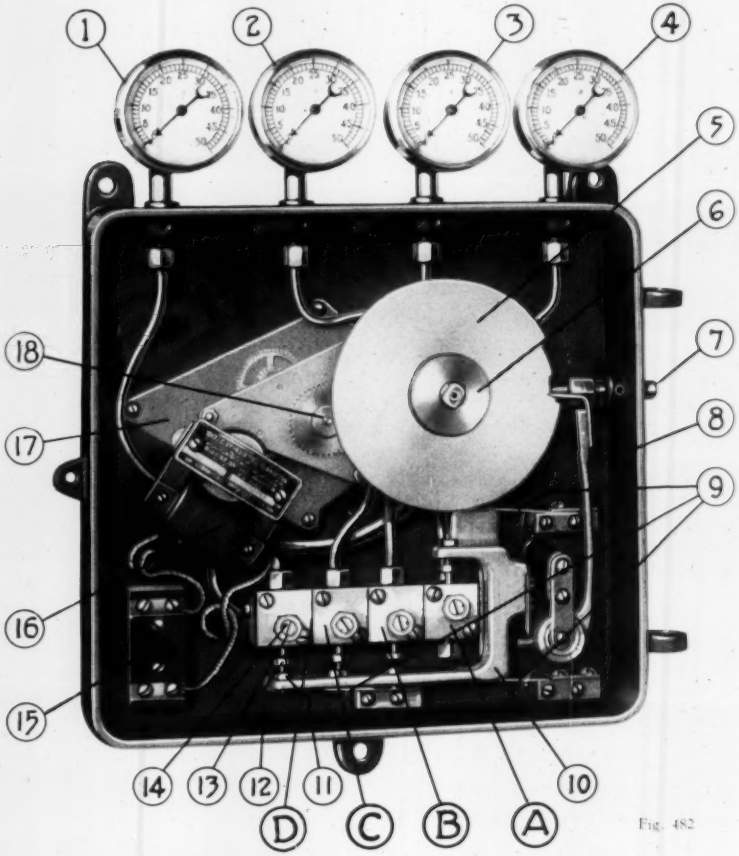


Fig. 482

position of tappet bar 10. Once adjusted they are locked in place with a locknut 11. Air valve A is inverted, resulting in its action being the reverse of valves B, C and D, for a given upward or downward movement of tappet bar 10.

The tappet bar is suspended on three flat, flexible stainless steel springs, 9. This three-point method of mounting causes a uniform vertical movement of the tappet bar, as compared with unequal travel of tappets when conventional pivot-type bearings are used. The bar is raised and lowered by a knife edge, through the movement of cam-follower 8. This uniform vertical movement permits the same depth of cut on the cam for any one of the air valves. This results in the simplification of tappet-bar adjustment; also the revision or the making of cams by the user, to accomodate changes in time schedule.

Steps are cut on the cam, corresponding to the number of air valves to be operated, and in the sequence in which they operate. Blank cams can readily be cut by the user to effect changes in the process cycle. When the total revolution is different, it will be necessary to change both gears and cams.

The cam is rotated by a Warren Telechron motor 16, through suitable gearing. The clock motor is sealed in oil and requires no attention whatever. By various combinations of gears and motor speeds the cam may be made to revolve in practically any desired time period.

The cam-driving gears are heavily constructed and are interchangeable, so that it is possible to rotate the cam at various speeds by changing the gears, which takes less than a minute.

Another recently developed air-operated sequencing controller is that of the C. J. Tagliabue Mfg. Co. One model, shown in Figs. 483 and 484, is designed especially for platen press operation, which application was described in detail in the March 1931 *India Rubber World*, from which the following is abstracted:

". . . The TAG Timer is shown in greater detail in the accompanying photographs. The view showing the door closed (Fig. 483) needs no explanation except as regards the small handle at the right hand side of the case. This is an emergency press-opening device. Should a workman become caught as the press is closing or if for any other reason he finds it necessary

Fig. 483

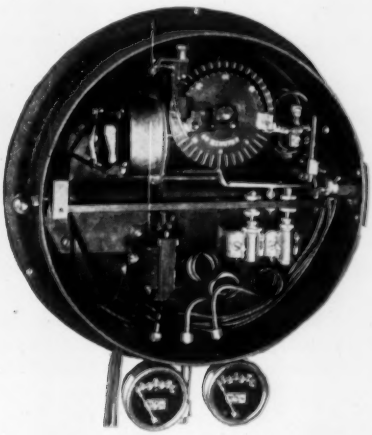


Fig. 484

to open the press after he has started the timer in operation, he simply turns this handle a quarter turn. Fig. 484 shows the construction inside the case, from which view it will be seen that the emergency lever turns a cam, thus forcing down the main lever, operating both pilot valves and opening the press. Once the emergency device has been used the press is locked in the open position until the foreman unlocks the controller door and releases a latch on the emergency. This prevents operators from using the emergency as a means of operating the press independently of the controller and thus shortening cures, which practice would, of course, defeat the whole idea of automatic timing.

"The internal construction of the controller consists of the electric clock, zero reset device, sub-lever, main lever and two pilot ball valves identical with those used in temperature controllers. These pilot valves are operated simultaneously but, as one is direct-acting and the other reverse-acting, air is admitted to one end and vented from the other end of the double-acting air cylinder of the Stuart valve. The air pressure employed is at 55-lb. pressure. Fig. 484 shows the internal construction of a platen press timer which not only opens the press at the end of the cure but which "bumps" the press at any point or points during the cure as often as the schedule calls for. The long concentric slot in the cam permits location of the bumping sections wherever desired. The bumping is performed just as a skillful operator would do it. The press is opened far enough to allow the escape of the gases which have been generated and then reclosed, this action being repeated as often as the bumping section has notches. Either type of controller may be quickly and easily reset for any cure from 1 to 40 minutes and longer cures can be arranged if necessary. . . .

"On certain types of work, it is desired to close the press with low pressure and maintain the low pressure for a certain definite time before putting on the high pressure for the balance of the cure. This has also been accomplished automatically . . "

Another model of Tagliabue sequencing controller, Fig. 485, is also designed for the rubber industry. It, too, employs compressed air, but electricity is additionally used for starting. Figs. 486 and 487 show typical tube vulcanizer applications diagrams:

. . . "This tube mold timer consists of a cam revolved by an electric (Telechron) clock with its contour cut to move a rider and related leverage in successive rises and drops, thereby operating a series of pilot air valves in the controller. These air valves are supplied with 25 lb. (sometimes 30 or 35 lb.) of clean air by the manifold on which they are mounted. By making the air valves direct-acting or reverse-acting, a rise on the cam will either cause them to vent the air from or exert it upon the diaphragm top of $\frac{1}{2}$" size three-way valves. The three-way diaphragm valves, of course, either admit the high pressure (90 or 100 lb.) air to the proper cylinder of the mold or to the tube itself or shut this supply and vent to atmosphere . . .

While the basic design of these timers is such that practically any sequence of events can be produced the requirements thus far are covered by four types of molds. . . . The installation for one type of mold is shown in Fig. 486 and the sequence is as follows:

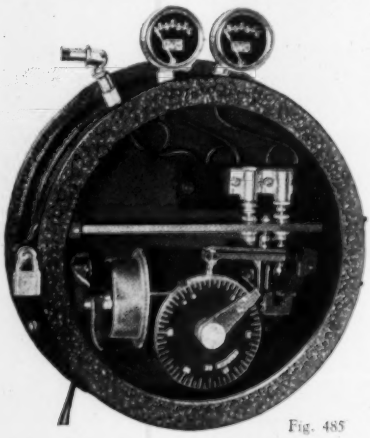


Fig. 485

Start of cure:

(1) Valve D vents air from upper end of closing cylinder F through check valve G which opens wide and weight of lid closes press. One end of locking cylinder E is also vented but locking cylinder does not operate because its other end is likewise vented.

Sometimes steps 2 and 3 were combined eliminating one pilot valve in timer and one diaphragm valve.

(2) Valve C admits air to left side of locking cylinder, locking the press, and simultaneously but more slowly inflates press diaphragm through an orifice so that the diaphragm inflation will not prevent the locking operation.

(3) Valve B admits air to tube.

Cure then proceeds and valve B vents tube before end of cure. At end of cure, valve C vents diaphragm and vents left side of locking cylinder which, however, does not move because there is no air pressure on other side. Finally valve B admits air to right side of locking cylinder (thus unlocking the press) and the air also goes through check valve to the top of the closing cylinder. But the check valve closes with air-flow in this direction and the air mist pass through the orifice, thus delaying the opening of the press until the unlocking operation has been completed . . .

The mechanical valves are part of the standard press equipment and being functioned by press movements they involve no critical timing but positively occur in proper sequence. Fig. 487 shows hook-up on another type of mold. The sequence is as follows:

Start of cure:

(1) Valves Y and Z operate simultaneously and oppositely. Valve Z admits air to closing cylinder which closes press door inasmuch as other end of this cylinder is vented through mechanical valve A which is open and valve Y which vents to atmosphere.

(2) As press door reaches closed position it pushes open valve B which admits air to left side of locking cylinder thus locking press. As piston of locking cylinder begins its movement it closes mechanical valve A.

(3) Valve X admits air to tube.

Cure then proceeds and valve X vents tube before end of cure.

At end of cure:

(1) Valves Y and Z operate simultaneously. Air from left side of locking cylinder and bottom of closing cylinder vents to atmosphere through valve Z. Valve Y admits air to right side of locking cylinder, unlocking press but it cannot open press because valve A is closed and will remain closed until unlocking is completed.

(2) At end of unlocking operation valve A opens, enabling the air to open press door in which it is assisted by a booster.

(3) As door begins to open valve B is closed in readiness for next cure.

In order to eliminate the possibility of air being passed to the tube before the press has been locked, a third mechanical valve is sometimes installed in the line between valve X and the tube. This valve is mechanically opened at the end of the locking stroke and remains open until the press unlocks at the termination of the cure . . .

In all such installations, either of two methods can be used for starting the controller. . . . Another method consists merely of a starting box with a lever handle, having an internal latch, double silver contacts and a pressure capsule which is connected to the first pilot valve operated in the timer. When the operator is ready to start the cure, he presses down on the lever handle which latches in the down position and closes the contacts. The contacts, being wired in series with the controller clock, start the timer and almost immediately the first pilot valve puts air in the line to which the capsule of the starting box is

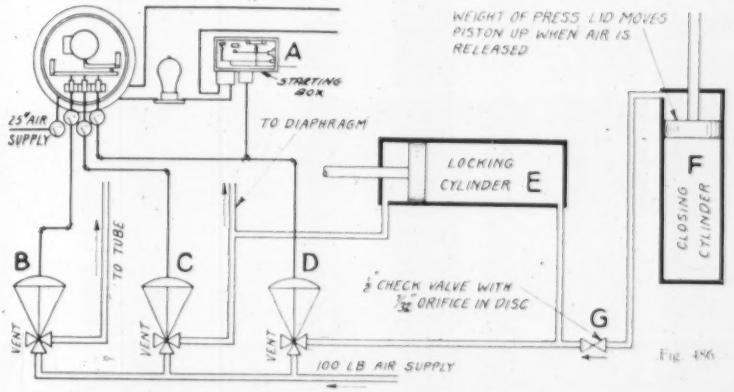


Fig. 486

connected. The inflation of this capsule restores the lever handle to its original position ready for the next cure—and also maintains the contacts closed until the end of the cure—at which time, when the timer vents the air from this line, the capsule deflates, opening the contacts and stopping the clock.

Until recently timers for this service had the cam cut so that it started the cure at the zero mark, went through the complete cycle of operations, and having made a complete revolution, came back to zero at which point the clock was stopped. The length of cure was definitely fixed by the reduction gearing between the cam and the electric clock whose revolution time

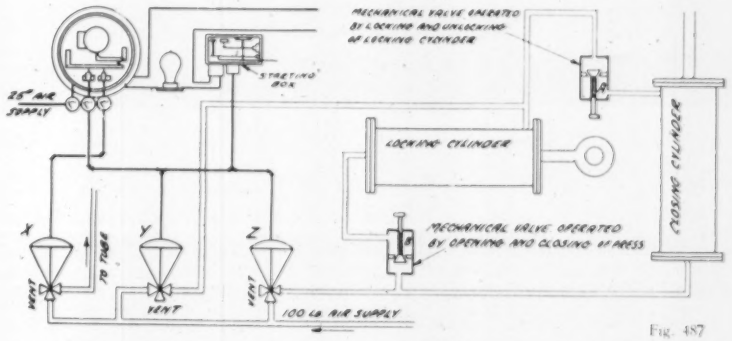


Fig. 487

could not be altered. Also the timing of events was permanently decided by the contour of the cam. Changes in cure length were accomplished by substituting new gear wheels and changes in intermediate timing by recutting the cam.

Demand for a quick and easy means of adjusting the timers in this respect and one which would not involve buying and waiting for new gears was met by the Tagliabue Fully Adjustable Timer. Instead of an electric motor only capable of rotating counter-clockwise, a reversible electric clock is used which rotates counter-clockwise during the first half of the cure, then reverses automatically and turns the cam clockwise back to zero where it again reverses (so as to be ready for the next cure) and immediately stops. This makes it possible to change the cure length in a few seconds' time for it is only necessary to reset the reversing arm at the new time on the cam, which is graduated in minutes. The period during which the tube is venting has also been made fully adjustable by having a separate cam sector (readily loosened, shifted and relocked) govern this operation. Those portions of the compound cam

which govern the operation of the closing cylinder, locking cylinder, etc., do not require adjustment as the timing of these operations is always the same regardless of the changes in the length of cure.

In this controller, a worm drive is used between clock and cam to eliminate the back lash present in spur gearing. Ball bearings are used not only for the two worm shaft bearings but also for the cam spindle, thus assuring perfect running at all times. A friction piece makes it possible to move the cam manually should this be desired.

7. Condition Time Curve Controllers

As was pointed out in Section 1, heading (*b*), there are numerous industrial applications calling not only for the "holding" control of processing conditions such as temperature, humidity, etc., but for definite condition-time curves obtained automatically, repeated at will and modified at will. This is the case, for example, in dyeing processes where research has shown that each particular class of dyestuff requires a scientifically worked out temperature curve in order to produce the best results in the way of exactitude of shade, fastness of color and other qualities the absence of which would mean a loss instead of a profit in the sale of the finished product. In the vulcanizing of rubber, controllers which regulate both temperature and pressure over a predetermined time cycle have made possible the use of modern "accelerators" which have both cut down the cost of the process and increased its efficiency. In the drying of many classes of materials a temperature-time cycle is often more important than the mere holding of the optimum maximum temperature. The sterilizing of evaporated milk, the boiling of size for warp sizing, and numerous other processes are all improved through the use of these controllers.

In the hardening of steel there is a critical stage where the absorption of heat by the steel without rise in its temperature, in the process of structural readjustment, suddenly breaks the curve recorded by a thermocouple in contact with the work, apart from the furnace temperature curve. Temperature-time control is of great value here too, but is effected by a special instrument not depending on a time cam, and this method (the Leeds & Northrup Hump Method) will be referred to separately at the end of this section.

Variable-condition or gradual-change controllers were first brought out by the C. J. Tagliabue Mfg. Co. a few years before the war and the first models embodied one cam (shaped to order at the factory) of such contour as to lift or lower a "rider" or contact arm or lever whose gradual motion altered the setting of a temperature controller of the air-operated type.

Fig. 488 shows one arrangement of the essential elements in a temperature-time controller (as made by the Taylor Instrument Companies). Cam B is for temperature setting and below it is the capsular spring C of the temperature-control tube-system.

Assuming that air-valve D is in a *fixed* position, its opening will be governed entirely by the movement of the capsular spring C. Since the amount of movement of the capsular spring and consequent opening of the air-valve is determined by the temperature in the apparatus, it follows that only sufficient air pressure can pass to the diaphragm-operated devices to maintain a *fixed* temperature in the apparatus. If however cam B were turned to the left, this would allow air to pass at an increased rate to the controlling device, resulting in a lower temperature in the apparatus. If cam B were turned to the right the expansion of C would have to be increased to open air-valve D. This adjustment would then cause a rise in temperature in the apparatus. Moving cam B from its original position causes a higher or lower temperature to be maintained, dependent upon the direction in which it is moved.

If cam B were driven by a clock mechanism and its contour cut in accordance with a predetermined time-and-temperature schedule, the changes of temperature in the apparatus would

be effected in accordance with the time-and-temperature schedule. Since the slightest movement of the capsular chamber affects the controlling temperature, it is evident that cam B would have to be cut to within such close limits that it would be impracticable. To accomplish the purpose in a practicable manner a larger cam A is used. The contour of this larger cam A is followed by the arm E, which is a member of a compound multiplying lever to which the air-valve D is fastened.

Such is the simplest form of a condition-time curve instrument and before passing on to the multiple-cam controllers it is not amiss to outline the possiblities of single-cam control. (The time-curve cam may be used in connection with the control of temperature, pressure, level, flow, voltage, etc., but only the possiblities of the temperature application will be described): With one eye on the clock and another on a thermometer, a man might

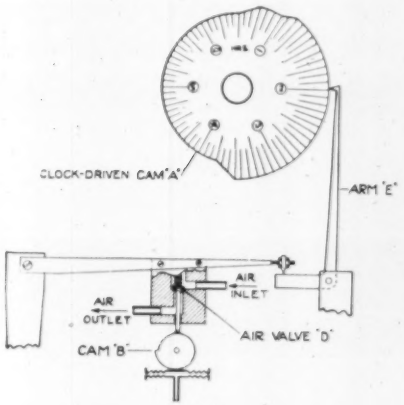


Fig. 488 (*Taylor Instrument Companies*)

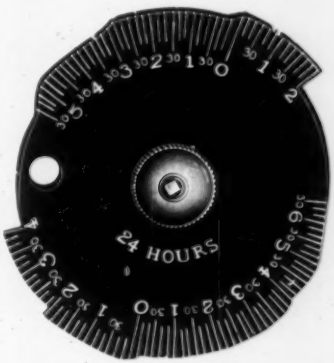


Fig. 489 (*C. J. Tagliabue Mfg. Co.*)

attempt to control the temperature in an apparatus in accordance with a schedule, by manipulating the setting key of a temperature controller, but with such manual changes of the setting point, only a rough approximation of the desired temperature curve or cycle would be obtained. Moreover, to repeat such a cycle again and again would be beyond human powers—the merest lapse of memory being immediately reflected in an irregular curve. The "memory" of the automatic controller is the rotating cam, on which the distance from the center to the edge determined the temperature at any given moment. Not only is it possible to produce a given temperature cycle again and again, but by merely selecting a different cam from any number, any other desired cycle can be produced. The only limitations are the range limits of the temperature controller tube-system, and the time limitation of the clock movement. To substitute one cam for another on the spindle of the clockwork takes but a moment.

At the end of the process or cure, the controller can ring a bell or flash a light, as desired, and, when so specified, blow-off the apparatus and admit cooling water—all with one cam. After the apparatus under control has been reloaded, resetting the cam automatically opens the steam inlet and closes the blow-off line and cooling water line, so that everything is in readiness for repetition of the process.

Not only is it easy to substitute one cam for another on the spindle, but even one cam may be used for more than one type of cycle. For example, let us assume a processing cycle covering two hours. With an 8-hour clockwork, a cam can be cut having three cycle contours on its periphery with ample room between. These can be stamped A, B, and C, and the man in charge of the process can use each at will, by simply tightening the cam so that the rider will be at the start of the desired contour.

Such a cam (Fig. 489) consisting of a metal disk of proper shape and nothing else, is known as a non-adjustable cam. By adding what is known as a "trip arm," a simple device positioned on the cam spindle next to the cam, we have what is known as a *semi-adjustable* cam (Fig. 490) which provides for an adjustable total duration of heating, the function of the trip arm being to throw the rider off (and thereby cause the heating medium to be shut off as explained in connection with the Foxboro timing feature, Fig. 460).

There are finally the fully *adjustable* cams (Fig. 491) provided not only with a trip arm but with a movable celluloid segment (transparent in order that the time graduations may be read through it) by means of which the very contour of the cam may be modified within certain limits. These adjustable cams are widely used in dyeing and other processes in which the optimum holding temperature, or temperature of the "boil", is fairly well known, while the duration of the rising period (from room temperature to the boil) requires a careful change for each class of dyestuff or of stock being dyed.

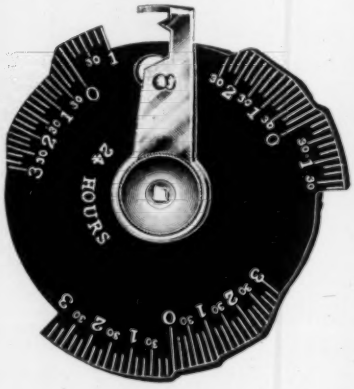
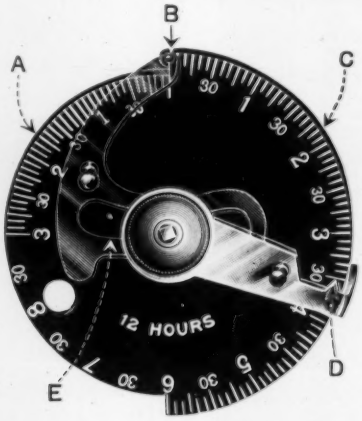


Fig. 490



(*C. J. Tagliabue Mfg. Co*

Fig. 491

A feature which must not be overlooked is that the temperature controller whose setting point is automatically raised, held, or lowered by the contour of the cam, may itself be adjusted within a range of several degrees, so that, for example, a "smooth" or plain circular portion of the edge of the cam may represent *any* desired temperature within the adjustment range.

It goes without saying that with properly insulated processing equipment and with proper installation of bulbs and other parts of the system, great exactitude of schedules is attained. The author has seen a series of recording thermometer charts taken from a rubber insulation vulcanizer thermometer which are so alike that the red temperature records appear to have been turned out in a printing press as were the green-ruled charts themselves. Once the chemist has developed the optimum schedule, he can safely trust the controller to repeat it again and again, provided only that the processing equipment itself is adequate and the installation properly made.

The foregoing statement of the results that may be accomplished with a single-cam temperature-time controller dimly suggests the possiblities of multiple cam controllers.

A temperature-time control method radically different from that described above (which assumes a *pre-determined curve*) is that invented and developed by the Leeds & Northrup Company for a process that presents a unique problem—the hardening of steel. Space limitations preclude more than a sketchy description abstracted from the 40-page L & N booklet on the subject:

While the steel is in the critical it absorbs heat but does not increase in temperature. During the critical, however, the furnace temperature rises. The difference between furnace and work is greater at the end of the critical than it was at its beginning, so that work heats faster above the critical than below it.

To illustrate: In Fig. 492, the line A B C D shows uniform rise in furnace temperature at a constant heat input. EF shows the resulting temperature rise of the work to the critical, FG the constant temperature in the critical and GH the more rapid heating above due to the greater temperature difference at J as compared with I. In Fig. 493, the line AB, BC and CD shows interrupted rise in furnace temperature with varied heat input. EF shows the resulting temperature rise of the work to the critical as in Fig. 492, FG the slightly longer duration of the critical and GH the rise above the critical at the same rate as below it, due to equal temperature differences at J and I. Also while the temperature rise M is the same in both figures, the time K and the time L are longer in Fig. 493, and will be constant for successive pieces,

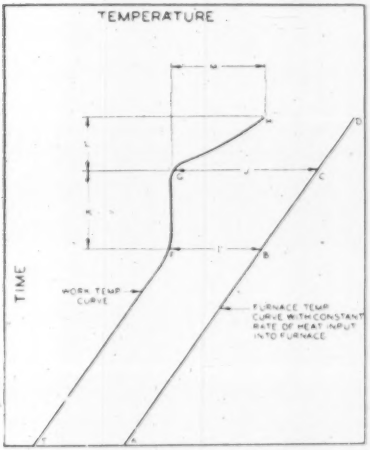


Fig. 492

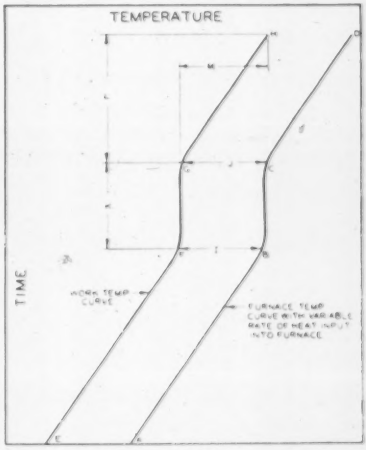


Fig. 493

because the temperature differences J and I remain equal, however long the critical may continue. Therefore, the ideal conditions which should exist in order to control or eliminate distortion (and change in physical dimensions) or breakage should be based upon the absolute control of the rate of heating and subsequent cooling of all parts of the tool. This control should allow the tool to be heated so that all sections, independent of their size and mass, reach the critical or change point together, leave it together and arrive at the quenching point together . . .

To control the rate of heating in and above the critical as precisely as below it, the manual setting for constant heat input can be elaborated. Where the nature of the work requires, input can be reduced as the hump begins and resumed as it ends, so that the temperature difference between work and furnace is not increased during the critical. This can be done manually with the regular hump equipment, but the human element may be eliminated by controlling the rate of heating automatically.

For this purpose we apply to the Hump Furnace, in place of a simple single-point temperature recorder, a combination recorder and recording controller. This instrument draws two dotted lines on the chart. One dotted line shows the temperature of the work and that of the furnace. This difference in temperature is controlled automatically to prevent the building up of an excess temperature difference between work and furnace at any point in the heating cycle . . .

The controller can be so set that this difference shall be the number of degrees required to give the desired rate of heating of the work. If it becomes greater, the heat input is reduced automatically. If it becomes less, the heat input is increased automatically. When cold work enters the hot furnace both curves drop while the work heats and the furnace cools, until the correct temperature difference is reached. Power is then turned on and the controller is in operation. The control or temperature-difference curve proceeds in a vertical line without variation while the temperature of the work rises correspondingly. While the temperature of the work is in the critical, however, it will be noted that the controller curve

becomes especially active although it retains its mean in a vertical direction. This is because it is then actively controlling the heat input to hold it below the established setting. Above the critical, the controller maintains the correct temperature difference, but without the activity shown in the previous stage, while the work curve proceeds at the correct rate from the end of the critical to the quenching point.

8. Combination Controllers

This section could be headed "Elaborate Time Control Systems," for the several assemblies of control equipment with which we conclude this chapter are composed of control units every one of which comes under one of the preceding sections—the condition-time curve units under Section 7, the sequencing units under 6 and the plain timing features under 5. While there is "nothing new" in their various elements, some of these combination instruments probably represent the finest expressions of inventive genius to be observed in the field of automaticity. Those included below have not been selected by the author as ingenious curiosities, however, but solely as exhibits suggesting practical industrial utilizations in more extensive fields of applicability.

Fig. 495 is the diagram of a horizontal vulcanizer application of the Tayl or Instrument Companies' Thermo-Tyme automatic controller (double-system, with blow-off feature) and Fig. 494 lists the elements of the standard installation which includes an industrial thermometer and a two-pen temperature recorder.

The controller brings the temperature in the vulcanizer up gradually over a definite period of time as desired and at the same time discharges the condensation, insuring good circulation and more uniform temperature in the vulcanizer.

Cams. This controller when used on tire and inner-tube vulcanizers controls an adjustable differential between the temperature in the vulcanizer and the temperature of the discharge condensate. If schedules have the same characteristics, that is if the condensate-discharge temperature and vulcanizer temperature has a fixed differential, but one cam is required. If the time and temperature schedules are different two cams are necessary. Cams can be constructed to take care of any cure.

Valves. Air-operated diaphragm valves are employed to control the supply of steam and cooling water. They also control the condensation discharge and operate the blow-off and emergency shut-offs.

Blow-off Feature. At the end of the cure a reverse-acting blow-off attachment causes the steam to be shut-off, blows off the steam in the vulcanizer and when the heater has been properly cooled it shuts off the cooling-water supply. It can also be arranged to operate a signaling device to warn the operator that the process is over.

KEY	DESCRIPTION	CAT. SERIES NUMBER
A-7	"AR-RECORD RECORDING THERMOMETER (VT)	11064
A-14	RECORDING THERMO. BULB (VT)	
C-1	STRAIGHT STEM THERMOMETER	
R6-3	THERMO-TYME TEMP REG (CONTROLLING & SAFETY ACTION)	15404
Q-1	MULTI-DISC CONDENSATION CHAMBER	18051
Q-2	STEAM CIRCULATING POCKET	18043
Q-8	ARMORED CAPILLARY TUBING	
Q-9	REGULATOR BULB (VT)	
Q-10	CONTROLLED PRESSURE LINE	
Q-20	½" MONEL METAL CIRCULATION PLUG	
R-1	MAIN AIR SUPPLY LINE (½")	
R-1₁	"CONDENSATION" AIR LINE (¾")	
R-1₂	"LIVE STEAM" AIR LINE (¾")	
R-1₃	"BLOW-OFF" AIR LINE (¾")	
R-2	MAIN AIR SUPPLY GAUGE	18080
R-2₁	"CONDENSATION" AIR GAUGE	"
R-2₂	"LIVE STEAM" AIR GAUGE	"
R-2₃	"BLOW-OFF" AIR GAUGE	"
R-4	AIR STRAINER	18025
R-6	AIR STOP COCK (¾")	18061
R-7	" PET " (¾")	18071
R-8	3-WAY STOP COCK (¾")	18023
R-9	ELECTRO-PNEUMATIC SWITCH (REVERSE ACT)	18010-R
R-13	ELECTRIC CIRCUIT	
R-16	" SIGNAL	
R-18	3-WAY PILOT VALVE (¾")	18024
S-1	STEAM INLET	
S-3	WATER INLET	
S-4	DRAIN	
S-5	HAND VALVE	
S-6	CHECK VALVE	
S-7	GATE VALVE (CLEAN-OUT)	
S-10	BY-PASS	
S-12	CONDENSATION DISCHARGE	
S-13	BLOW-OFF (CONTROLLED)	
S-17	INSULATED PIPE LINE	
T-1	DIRECT ACTION DIAPHRAGM VALVE	18100
T-3	" " T & T "	18101
T-4	REVERSE " DIAPHRAGM "	18104
U-1	HORIZONTAL VULCANIZER	
V-1	PANEL BOARD	

Fig. 494

An important use for combination cycle controllers is the "staggering" or rotating of phases or stages of batch processes carried on in batteries of processing units, in order to provide the requisite condition curve in each unit and also to attain or approximate an *even flow of material to and from the battery as a whole* in spite of the fact that each unit is fed intermittently and delivers intermittently. A four-vat battery of batch pasteurizers is

an interesting example. Such installations have been equipped by the Tagliabue Co. with twelve-cam controllers having four sets of three cams all on one shaft, each set of three comprising an inlet valve cam, an outlet valve cam (both "contact" type) and a temperature cam of the "curve" type.

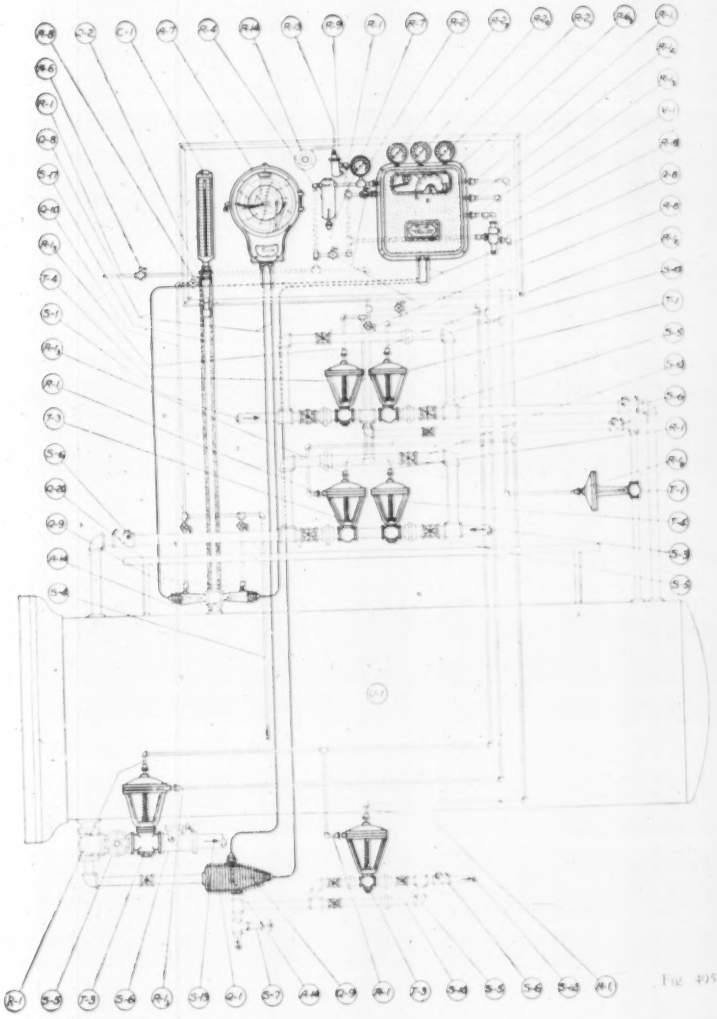


Fig. 405

What happens in each vat is as follows: (a) The inlet valve is opened while the outlet valve is held closed; the temperature is gently raised; (b) inlet valve closes, temperature raised to 144° in ten minutes; (c) both valves closed, temperature held at 144° for thirty minutes; (d) heat shut off, outlet valve opens for twenty-minute emptying period. The complete cycle for the battery of four vats takes eighty minutes and the vats are emptied in turn, providing a continuous delivery flow to the coolers and bottle-filling machines.

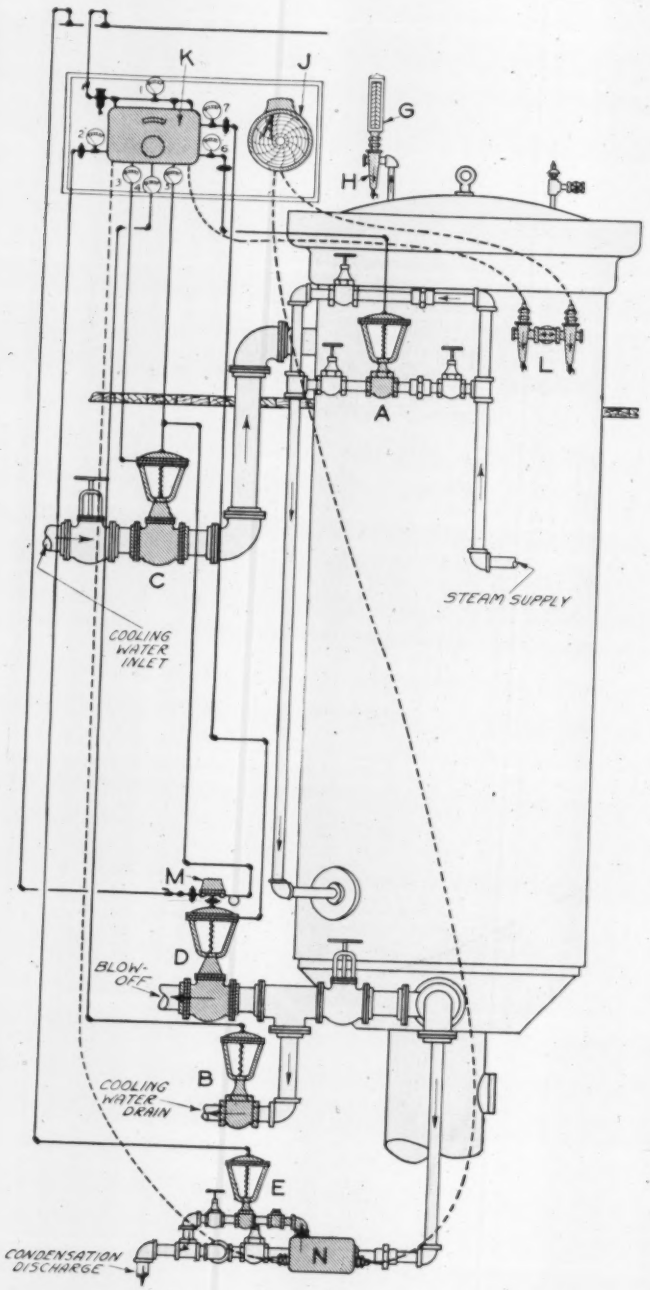

K
J
G
H
L
A
C
STEAM SUPPLY
COOLING WATER INLET
M
D
BLOW-OFF
B
COOLING WATER DRAIN
E
CONDENSATION DISCHARGE
N

Fig. 495

Another interestingly worked out standard installation combining two temperature-time control units with sequence control (in which some events are timed absolutely and others relatively to conditions) is that of the C. J. Tagliabue Mfg. Co. for vertical tire vulcanizing presses. Fig. 496 shows the hook-up, with diaphragm-motor valves A, B, C, D and E operated by double-system temperature-time controller K which is described in part as follows:

This controller is the No. 260 plus added features. To emphasize these, let us briefly review what the No. 260 does: The No. 260, by means of one temperature control system, takes care of the press temperature throughout a predetermined schedule. It also has a second or "condensation temperature" system. It ends the cure at the desired time; and it then blows off the press. This leaves two jobs for the heater man to do: (1) Cooling—by flooding or spray—for a definite length of time; (2) Draining. It was to make these manual operations equally automatic that the No. 280 was designed. The front cam is identical with the one cam of No. 260 controller. The added back cam operates the various water valves and is adjustable for duration of cooling and draining as required.

The operation of the valves is charted in Fig. 497. The control cycle is as follows:

During Cure—Steam Inlet Valve A throttles to maintain temperature cycle. Condensation Valve E removes wet steam. Cooling Water Inlet Valve C, Water Drain Valve B and Blow-Off Valve D remain closed.

AUTOMATIC OPERATION	DIAPHRAGM MOTOR VALVE POSITIONS				
	STEAM INLET DIR ACT O.M.V. A	CONDENSATION DISCHARGE DIR ACT O.M.V. E	BLOW-OFF DIR ACT O.M.V. D	WATER INLET DIR ACT O.M.V. C	WATER DRAIN DIR ACT O.M.V. B
START OF CURE	OPEN	OPEN	SHUT	SHUT	SHUT
DURING CURE	OPEN THROTTLING OR CLOSING	OPEN THROTTLING OR CLOSING	SHUT	SHUT	SHUT
END OF CURE	SHUT	SHUT	OPEN	SHUT	SHUT
AT END OF VARIABLE PERIOD OF TIME COOLING WATER ENTERS	SHUT	SHUT	SHUT	OPEN	SHUT
AT END OF 2ND VARIABLE PERIOD OF TIME COOLING WATER DRAIN OPENS	SHUT	SHUT	SHUT	OPEN	OPEN
AT END OF 3RD VARIABLE PERIOD OF TIME COOLING WATER SHUTS OFF	SHUT	SHUT	SHUT	SHUT	OPEN

Fig. 497

At End of Cure—Steam Inlet Valve A and Condensation Valve E close and remain closed thereafter. Blow-Off Valve D opens. Cooling Water Inlet Valve C and Cooling Water Drain Valve B remain closed.

At End of First Variable Period—Blow-Off Valve D closes and remains closed thereafter. Cooling Water Inlet Valve C opens. Cooling Water Drain Valve B remains closed allowing water to partially fill up (or "flood") tire press.

At End of Second Variable Period—Cooling Water Inlet Valve C remains open. Cooling Water Drain Valve B opens and remains open thereafter.

At End of Third Variable Period—Cooling Water Inlet Valve C closes. Then clock stops.

When Controller is Reset for Next Cure—Cooling Water Drain Valve B closes. Steam Inlet Valve A and condensation Valve E open wide (as press is comparatively cold). All other valves are closed.

The arrangement shown in Fig. 497 is for the "flood" method of cooling after cure. For vulcanizers cooled by the "spray" method, drain valve B may be equipped with a duplex top like that of blow-off valve D and these tops interlocked so that cooling water (often contaminated) will not discharge into the hot wells, but will drain to sewer; also to prevent steam pressure in blow-off header from blowing back into one vulcanizer when others are blown off.

There have recently been developed combination cycle controllers which not only provide the optimum temperature-time curves and otherwise bring about the complete curing cycle, but automatically supervise interlocking safety features and automatically perform specified tests to "see that everything is right" before the processing cycle is begun. Fig. 498 shows a Tagliabue combination cycle controller designed for installation on a tire press in which each tire is expanded into its mold by an air bag. This makes it necessary to regulate hydraulic pressure, high-pressure air inside the bags, and low-pressure air for steam-valve operation, in addition

to the temperature cycle regulation which includes a heating period, holding period, blow-off of steam, admission and draining of cooling water and final mold-warming. Typical specifications as laid down by a tire manufacturer are as follows:

"Fill air bags in five minutes; one minute to test for air leakage in bags (5-lb drop permissible); thirty minutes to rise to vulcanizing temperature; two hours hold at that temperature; three minutes to blow down steam; thirty minutes opening of water inlet and water drain for cooling; ten minutes to warm molds to facilitate removal of tires. And throughout the entire cure, whevever the hydraulic pressure drops from 1500 lb to 1200 lb, the controller shall automatically relieve the bag pressure."

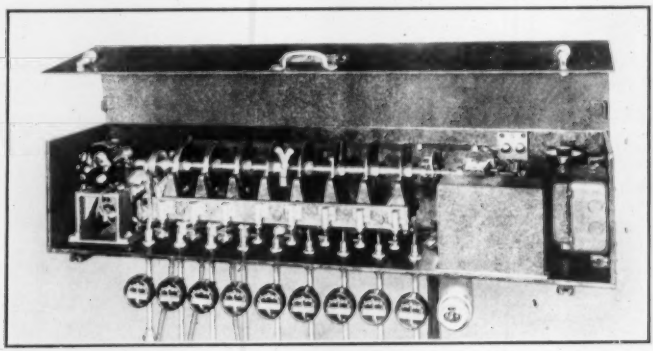


Fig. 498

The controller performs all of these functions, so that manual labor is required only for loading and unloading the tire press. The automatic test called for in the specifications is performed by the controller in the following manner: The main cam shaft is rotated to the starting point by a motor, and stopped. Immediately a separate electric clock starts to rotate the leak test cam, opening a valve admitting air to the bags. At the end of five minutes this valve closes. At the end of another minute, if the air bag pressure falls, the clock stops and a red light summons the attendant who must correct the faulty condition and re-start the test cam clock so that the bag leak test repeats itself; but if the bags again show a pressure drop exceeding five pounds, the controller will again stop and the red lamp again flash. Another safety provision is an auxiliary or standby steam inlet temperature control system which comes into action and handles the cure should the regular system become inactive for any reason. A white light shows when the current is on, and a green light flashes only at the end of the complete cycle of events, notifying the attendant that the press may be opened for removal of molds.

The foregoing application is noteworthy not only for the complexity of the automatic operations but for the automatic interlock of safety features. The complete cycle covers more than two and a half hours. A striking contrast is afforded by another rubber curing application—a five high platen press for rubber heels. Operators of such presses are paid for every heel of good quality produced. The principal function of the cycle controller is to time the cure to the second. The press cannot be opened during the cure, but it opens automatically at the end of the cure, and a signal lamp moreover lights 15 seconds before the end. Safety interlock of all steam, air and high and low hydraulic ram pressure lines is also provided.

In order to bring about complicated schedules controlling operations requiring considerable power, the automatic controller grows beyond the usual dimensions of an instrument and almost attains the size and appearance of the auxiliaries department in a power plant. The Freyn Engineering Company's blast furnace Charging Control System, for example, comprises in addition to a sequence control instrument a number of other units including the control panel shown in Fig. 499. This charging control system

is a complete equipment for automatically coördinating and sequencing the various operations involved in charging a blast furnace. It may include equipment for automatic weighing and charging of the coke; and it is used with air-operated, steam-operated, oil-operated and electrically-operated devices. Brief extracts from the Company's description, while of necessity going beyond the description of the controller itself, reveal the possibilities of time cycle control on industrial applications:

This blast furnace charging control system automatically sequences and interlocks the various operations involved in charging the furnace so that only one man per turn is required for charging. This man operates the scale car and starts the skip hoist on its way after dumping material into it. All other parts of the charging equipment are interlocked so that they can operate only in proper sequence. They are caused to operate in this proper sequence. Should any part of the charging system fail to operate, the remainder of the equipment is automatically caused to stop thereby preventing the piling up of material at some point in the charging system.

The principal elements of this charging system consist of the following:

1. Motor-driven valve operating mechanism for controlling valve or four-way cock governing the flow of air, steam or oil to small bell hoist.
2. Duplicate equipment for large bell hoist.
3. Interlocking control, consisting of:
   a) Revolving distributor and slow-down interlock.
   b) Skip interlocking.
   c) Bell interlocking.
   d) Faceplate interlocking.
4. Sequence control.
5. Small bell control.
6. Large bell control.
7. Signal system for indicating number of dumps made by small bell.
8. Transfer switch equipment for quickly transferring from automatic to manual control.
9. A push-button switch is provided for permitting extra skip loads without disturbing the automatic operation.

The Valve Operator comprises a motor-driven speed reducer mounted on a bed-plate and equipped with limit switches and a crank for operating the valve lever.

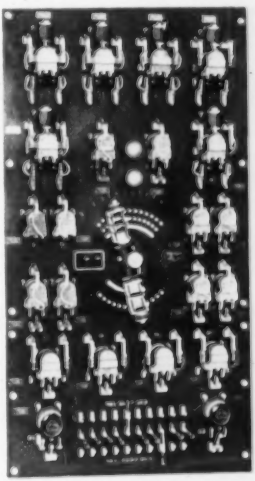


Fig. 499

Four interlocking controls are furnished: (1) For interlocking the distributor with the skip hoist, so that the skip cannot be hoisted until the distributor stops revolving, and to stop the skip at slow-down in case the small bell should not be closed. (2) For interlocking the small bell with the skip, causing the skip to suspend operation, in case the small bell does not function. (3) For interlocking in a similar manner the operation of the large bell with that of the small bell, thereby preventing the operation of the small bell in case the large bell fails to function. (4) For interlocking the operate of the faceplate so that the faceplate arm must move one segment for each dump of the small bell, otherwise the succeeding dump of small bell is prevented, which in turn stops the skip at slowdown.

The purpose of the Sequence Controller is to accomplish the operation of the large bell in response to the operation of the small bell in such manner that the large bell will be operated after predetermined numbers of operations of the small bell. The arrangement provides that the small bell may make a pre-determined number of dumps, followed by the dumping of the large bell, and may then make another pre-determined number of trips, again followed by the dumping of the large bell. The number of dumps first mentioned may differ from the number of dumps second mentioned. Thus, it may be possible for the small bell to make four dumps, followed by the dumping of the large bell, and then for the small bell to make five dumps, followed by the dumping of the large bell, this cycle being repeated indefinitely. Control provides that the number of dumps of small bell prior to the first dump of large bell, and the number of dumps of small bell prior to the second dump of large bell, may be individually selected within limits determined by the amount of control equipment provided. With the standard arrangement, the maximum number of dumps of the small bell during a complete round is ten. This control consists of a faceplate having a motor-driven arm moving across it. The arm carries a brush or contact finger so arranged to engage with nine contact

segments arranged in a row in the direction of travel of the arm. Near the completion of each dump of the small bell, the motor causes the arm to move over one segment. Connecting to the segments are ten single-pole, double-throw selector switches. These switches are provided for selecting the number of dumps of the small bell before the large bell is caused to dump.

Small Bell Control. Two contactors are provided for controlling the valve operating mechanism governing the operation of the four-way cock for the small bell.

Large Bell Control. Likewise, in the case of the large bell, similar equipment is provided for controlling the valve operating mechanism.

The *Signal System* comprises a ten-light lamp target indicator, which lights up to indicate the number of dumps of the small bell that have been made in a given round.

The mode of operation of the sequence control is as follows: Upon the completion of the first dump of the small bell in a round, the faceplate arm is moved over one segment of the small bell, the arm is moved over successive segments, successively completing circuits in sequence to the individual selector switches. When the faceplate arm has moved far enough to reach a segment connecting to a selector switch that is closed, a circuit is completed for energizing the stock-line recorder control, causing withdrawal of the test rod. When test rod reaches its uppermost position, a circuit is completed for energizing the large bell control, thereby causing the large bell to dump for the first time in the round. After the faceplate arm has moved over enough segments to reach the second selector switch that is closed, a circuit is completed to cause the large bell to dump for the second and final time in the round. At the time the large bell makes its final dump for the round, the motor driving the faceplate is reversed, causing the arm to return to the zero or starting position for a new round.

Provision is made so that the large bell cannot open unless the small bell is closed. Also by means of the bell interlocking control, the small bell is prevented from operating until the large bell is closed. The bell interlocking is energized from the sequence control and when actuated, prevents further operation of the small bell after it has completed the dump on which it may then be engaged until the large bell has operated. As soon as the small bell is closed, the large bell will open and close, and upon closure of the latter, the bell interlocking will function to permit further operation of the small bell.

Should the large bell fail to dump or fail to complete its dump, the bell interlocking will prevent the small bell from operating. If the small bell does not dump, the skip interlocking will stop the skip at slow-down. *Hence, it is seen that not only are the operations of the skip, revolving distributor and large and small bell sequenced so that they occur in order, but also they are checked so that should any part fail to operate, the cycle is interrupted and stopped.* This prevents dumping more than one skip load on the small bell before the latter operates, and also prevents dumping more than the predetermined number of loads on the large bell before the latter is dumped.

A series of ten lights, placed in a lamp target, to be installed at a point convenient for observation by the scale car operator, shows at all times how many loads have been completed in the current round so that the operator is constantly advised of his position in the sequence without depending upon memory.

INSTRUMENTS BOOK SHELF

The books reviewed in this section can be supplied by the Instruments Publishing Company.

Handbook of Steam Flow Measurement. *L. K. Spink.* The Foxboro Co., Foxboro, Mass., 1931, Paper 5¼x7¾ inches, 48 pages. Gratis.

Mr. Spink, the Manager of the Flow Meter Department of The Foxboro Company, has condensed into a convenient flexible pocket booklet the essentials of this subject—and in an original manner which should prove attractively interesting to the practical man without by any means failing to reach the level of theoretical presentation which the most erudite graduate engineer may expect. This booklet contains within its small number of pages complete formulae for the computation of steam flow. The computations are arranged in two parts—for constant pressure applications and for fluctuating pressure applications. All of the necessary correction and coefficient tables are given. The fundamental theory of the orifice-type meter is described and also various types of primary devices which are used in the installations. There are things to critize in the make-up but they are probably not Mr. Spink's fault: for example the first table is numbered X and it is followed by Table Xa then, eleven pages later, by Table IIA, while the useful five-page table of density multipliers for saturated steam—and others—are not numbered at all. But these and similar slips are probably first-edition "bugs" and do not detract from the value of this little treatise. —M. F. Béhar

NEW INSTRUMENTS

Recently Developed by Instrument Manufacturers

Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional Information

New Potentiometer Pyrometer

*Thomas R. Harrison**

A NEW potentiometer pyrometer in indicating, recording, multiple recording, and controlling types has been developed by the Brown Instrument Company.

There are two general types of thermo-electric pyrometers—the millivoltmeter and the potentiometer. For certain requirements, the millivoltmeter type is more suitable, whereas for other requirements, the potentiometer type is preferable.

The new Brown Potentiometer has some 55 features which are new in potentiometer pyrometers, the most important of which are described below. High accuracy, easily maintained throughout the life of the instrument, was considered to be of prime importance in its design.

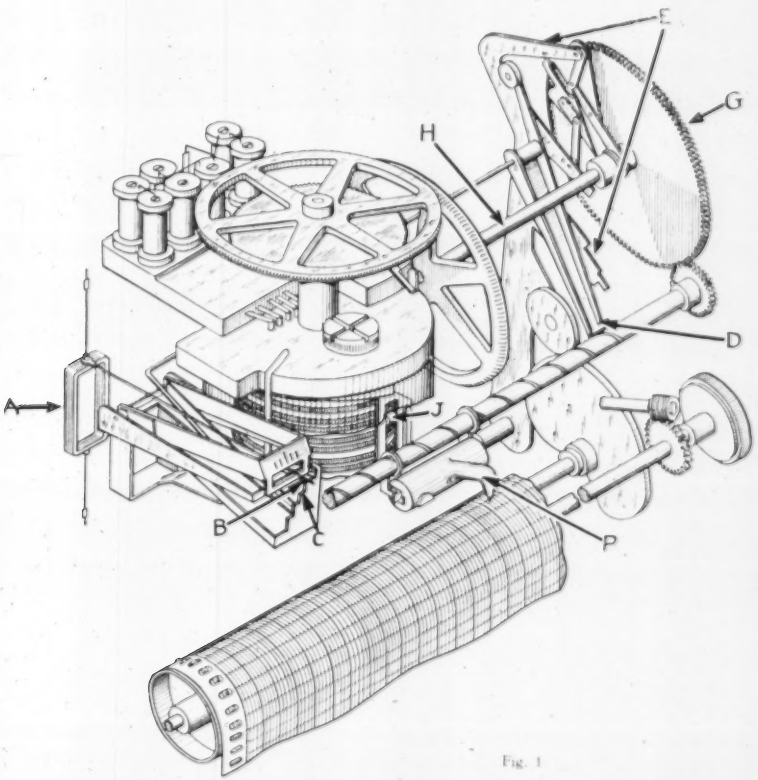


Fig. 1

Fig. 1 illustrates the operation of the new Brown potentiometer pyrometer, a null-type potentiometer in which the galvanometer A directs the operation of mechanism to rebalance the circuit for each change in emf that is measured.

*Director of Research, Brown Instrument Co.

At intervals of every few seconds, the galvanometer pointer B is lightly clamped. A step on the selector table C rests gently against the pointer and positions a rugged secondary pointer D. The step lever E periodically moves downward into contact with the secondary pointer and rotates gear G secured to shaft H. The amount of rotation depends upon the position of the secondary pointer. The rotation of shaft H readjusts the slide wire contact J and simultaneously moves the pen P.

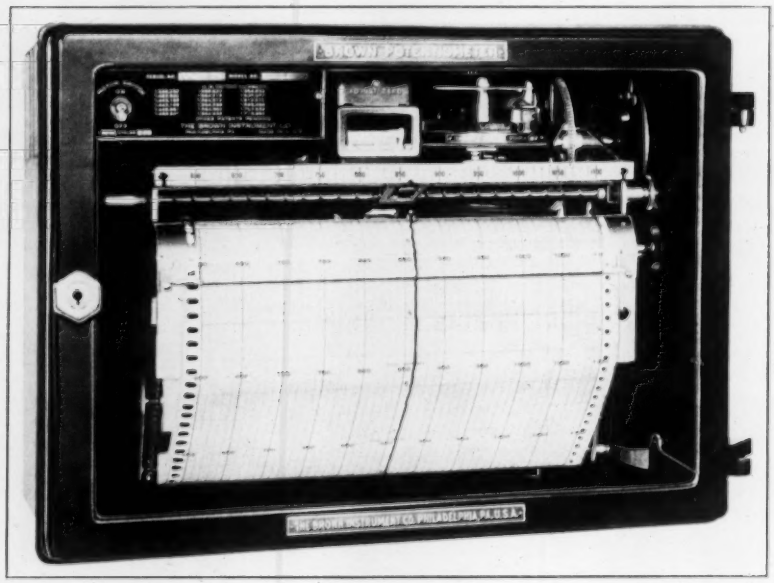


Fig. 2

The Brown galvanometer is designed to have a uniformly high responsiveness under all practical operating conditions. The balancing mechanism exerts no strain upon the galvanometer pointer and the mechanical movements of the secondary pointer are comparatively large. As a result, no adjustments are needed to take up the wear on either the pointer or contacting mechanism and the highest accuracy is maintained over long periods of continuous operation.

The charts and scales 12″ wide, were produced with great care to conform to the latest calibration values for Iron-Constantan, Chromel-Alumel, and Platinum-Rhodium thermocouples. In order to derive full benefit from these carefully made charts, it is necessary to make suitable corrections for the natural expansion and contraction of the chart paper that takes place with changes in atmospheric humidity. It is because of this expansion and contraction that strip charts have oblong holes at one side of the paper. Such expansion and contraction can cause errors of over 1% of the reading of some chart ranges unless corrections are made. To eliminate such errors, a humidity compensator is built into the instrument and this automatically corrects the pen position and brings it into proper register with respect to the chart markings. Also, the charts are printed under a standard condition of humidity. The new Brown potentiometer is believed to be the only recording instrument having this feature.

Another original feature in the Brown potentiometer is the sturdy, dust-proof case that is equally suitable for wall mounting, front-of-board mounting, flush type panel mounting, or table mounting. The same instrument may be procured for wall mounting and subsequently mounted flush on a panel board. The instrument door has a handle containing a lock so that the door may be locked or not as desired.

The case is entirely enclosed and there are no openings through which the chart must extend. A re-roll attachment for the chart is standard and can be used if preferred, or the chart may be allowed to accumulate in the bottom of the case. An ample expanse of the record line is always exposed to view.

The galvanometer is completely enclosed in an inside compartment with a glass window, giving it full protection from mechanical injury and from air currents when the door is open.

The galvanometer pointer and suspensions are relieved of practically all the work by the introduction of a "secondary pointer" system, wherein a rugged secondary pointer assumes a position in magnified proportion to the galvanometer pointer and then governs the adjustments of pen and slide-wire contact.

The slide wire is exceptionally long, 40 inches, which permits the use of a relatively large diameter wire. This reduces the effect of wear to a minimum, makes accurate operation easily maintained and permits more convolutions and consequently finer scale subdivisions, without increased resistance. The slide wire is in spiral form and enclosed in a glass container which can be filled with oil, insuring freedom from corrosion or fouling of the slide wire contact and further reducing wear to a minimum.

The pen is moved by a stainless steel shaft with a long spiral groove and is operated in conjunction with the slide-wire contact by means of a positive pawl-driven mechanism that cannot slip.

The long slide wire and the spiral shaft pen drive permit close settings of contact and pen with relatively large mechanical motions produced by the pawl-driven mechanism; thus the necessity for extremely close adjustments of the drive mechanism is obviated and the adjustments are not easily upset, as by wear.

Automatic control is obtained through mercury switches which can handle up to 50 amperes at 220 volts (60 amperes at 110 volts). As the mercury switches are sealed in glass, no open arcs occur and danger of fire and explosion is eliminated. The instrument may be provided with as many as 3 mercury switches, making it applicable to the operation of various valve control mechanisms or signal lights.

The control temperature is easily set by a knob projecting through the front of the door and this knob can be left in place or removed as desired.

Multiple recorders employ the color-code employed with other Brown Multiple Recorders. A new "balanced stroke" feature causes the record to be printed and the instrument connected to another thermocouple as soon as the proper balance adjustment has been reached. This results in more frequent printing and consequently more accurate and legible multiple records.

In the Brown potentiometer, the terminals for both the thermocouple wiring and the control circuits are in an enclosed terminal box with outlets for conduit wiring. A terminal block with a temperature equalizing metal insert is provided for the thermocouple cold junctions and compensator, to insure accurate cold junction compensation.

These examples of the many new features indicate the effort which has been made to design a rugged potentiometer pyrometer for severe industrial service and one which will have the extreme precision required in modern industrial measurements.

New Tapalog Recording Pyrometers

(Wilson-Maeulen Company, Inc.)

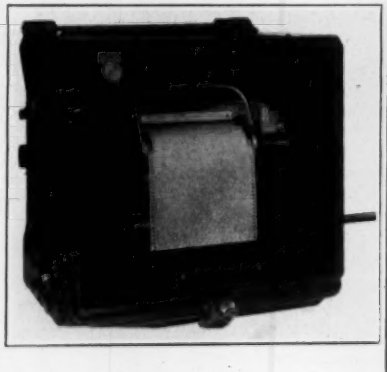
A NEW series of Tapalog recording pyrometers for single and multiple records, for either base-metal or rare-metal thermocouples, and for various temperature scales up to 3000° F. and equivalent C scales, has just been brought out by the Wilson-Maeulen Company, Inc.

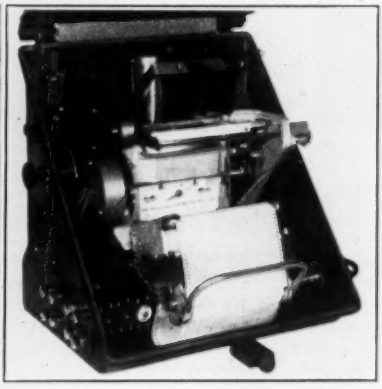
The Improved Tapalog has been entirely redesigned mechanically, to adapt it to the use of an improved industrial type of electric synchronous motor clock of excellent power output, which can be connected to lighting circuit or regular plant source of alternating current power. The Tapalog as now presented provides a recording cycle of greater frequency and a machine design remarkable for the small number of mechanical parts that constitute the simple and robust mechanism.

The chart is 6 inches wide for each record, whether single or multiple. The multiple design enables the full width of the chart to be used for each record, which is immediately visible as soon as printed. Each record on the multiple record Tapalog is printed in a different color, using color for record identification throughout. An endless belt of typewriter ribbon furnishes a means for printing that is never too wet or too dry, but always prints clear and plain records. The ribbon is underneath the chart paper and does not touch the pointer, so the pointer cannot collect ink and become sticky and dirty. The printing ribbons for multiple record machines have as many bands of different color as the number of records. In both the single and multiple record Tapalogs, the depressor prints the record every twelve seconds. In multiple record machines the thermocouple connections are switched after three

depressions, or after 36 seconds on one couple. Thus on a six record machine, (the maximum number of records on one instrument) the record is absent from any couple only 180 seconds or 3 minutes. Multiple recorders of fewer records than six have a correspondingly greater frequency of cycle. Tapalogs can be ordered for chart speeds of 1" per hour or 2" per hour as desired.

The galvanometer is a high resistance movement of "mono-pivot" design retaining the single bearing principle that has contributed much to the success of Wilson-Maeulen pyrometers. The mono-pivot moving system can be heavier than any other type, and permits a rigid metal frame to be used for the moving coil. This supports the coil and prevents it from warping or getting out of shape from the effects of heat or moisture. Stability of calibration and durability are thus assured. A clamping mechanism, obtainable only with mono-pivot galvanometers, disengages the pivot from the jewel bearing, and firmly holds the moving system during shipment and handling of the instrument, and prevents injury to the moving system and its finely constructed and polished jewel bearing.





The electrical commutator portion of the automatic switch is the same reliable design that has provided perfect thermocouple contacts in Tapalogs for a number of years. Solid gold wire segments wound on a molded bakelite drum, and platinum faced brushes, are the elements of the multiple switch. The mechanical escapement and switch shifting device of former models has been replaced by a simpler and sturdier escapement mechanism which is incorporated in the clock unit and which is connected to the electrical commutator portion of the switch only by a loose link shaft, so that either may be removed without disturbing the other.

The electrical automatic cold junction compensator, through a Wheatstone bridge circuit having one coil variable in resistance in proportion to temperature, automatically corrects the current from the thermocouple, eliminating errors due to changes of the thermocouple cold junction temperature. This automatic electrical compensator is contained in the Tapalog case, and installation is greatly simplified, since buried cold junctions, thermostats, water cooling systems, and all other methods of stabilizing cold junction temperatures are unnecessary. The Wheatstone bridge method of cold junction compensation is scientifically correct and accurate in principle.

The case opens diagonally, allowing complete access for inserting new rolls and ribbons, and a simple, convenient arrangement for lowering the paper carriage allows charts and ribbons to be easily changed, and all parts of the mechanism are easily accessible for adjustment. Convenient eyelets in the case casting permit the case to be locked if desired. The main frame and support brackets of the Tapalog are strong aluminum alloy castings of generous size, machined to precision limits, forming a rugged support for the assembled mechanism. The whole machine is well protected by a heavy cast case, rubber gasketed to keep out dust and moisture, and with heavy glass windows to admit plenty of light.

The Tapalog with its black enameled case, polished windows, and finely finished mechanism, presents a splendid appearance of fitness for long and reliable operation.

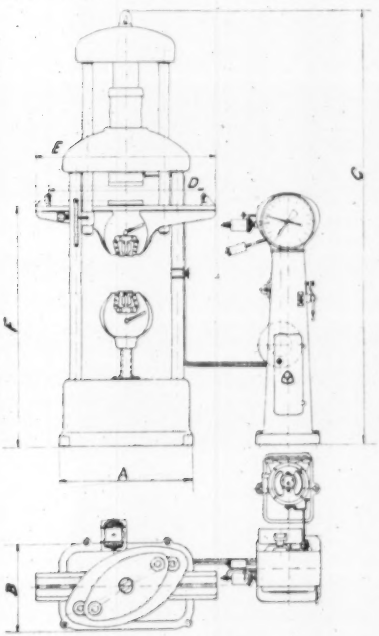
Hydraulic Universal Tester

(Alfred Suter)

IN designing this machine the Losenhausenwerk aimed at producing as compact and accurate a machine as could be produced for making tensile, compression, buckling, transverse, folding, shearing and cupping tests.

It consists of three parts: the tester itself, the pendulum load registering device and the hydraulic pump.

The *testing machine* consists of a strong cast iron base on which are mounted two well dimensioned uprights, on the upper part of which the cast iron head is fitted. This latter carries the pressure cylinder. A finely ground-in piston projects from this cylinder and transmits the pressure applied to the pressure head, from it to the upper gripping head by means of two connecting rods. The upper gripping head is also built as a transverse test table and also carries the lower compression platen, the upper one being set into the base of the cylinder.



This combined tensile and transverse table is guided by two rollers running in ball bearings.

A scale mounted on the left upright indicates the distance between gripping heads and compression platens. These distances, normally 10" can be had in any larger size desired.

The lower tensile gripping head can be moved up and down by means of a spindle set into the base of the machine. It can be raised or lowered by means of a hand crank or by means of a motor driven worm drive.

The tensile gripping heads are of a ovenl construction which enables one to insert the test specimen from in front of the machine directly into its appointed position. It is therefore not necessary to move it up and down to locate it properly.

The *pendulum load measuring* device consists of a cast iron housing on which the pendulum is mounted. The pressure created in the cylinder of the testing machine is brought to the pendulum by means of a small copper pipe connected with the measuring cylinder, and in the latter a finely ground-in piston transmits it to the pendulum and the indicator hand of the dial.

In order to eliminate all lateral stresses in measuring the loads, an intermediate cylinder is provided, which is rotated by a separate motor drive.

The pendulum carries detachable weights at its lower end, so that by using all, part or none one has three load ranges, i. e. full capacity, ½ and 1/5th or only 1/10th.

The *hydraulic pump*. This pump which is direct motor driven is of a novel design. It is of the multi-piston type and runs at about 100 strokes per second, so that its pulsations are completely lost and one has an absolutely even increment of load and working speed.

In this pump the volume of oil which is being compressed is regulated and this is done without valves.

The whole pump is immersed in the oil reservoir.

A tachometer is mounted on the stand and besides an electric starting switch one needs only to raise a lever to start a test, and to set this lever at the proper height when the desired working speed has been attained.

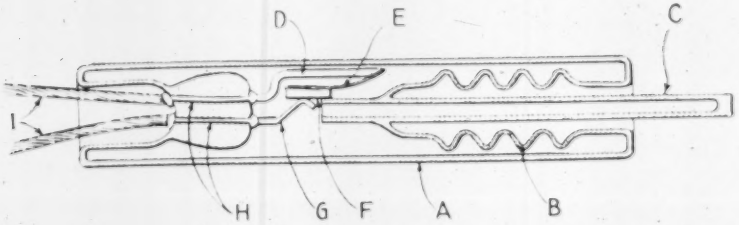
This equipment can also be supplied with a device for holding the load constant over any given length of time and also with equipment for making alternating load or pulsating tests.

New Vacuum Contact

(*Burgess Battery Company*)

THE Burgess vacuum contact is a new and improved device for use wherever a positive, rapid and durable electrical contact is required in circuits handling up to 6 amperes continuous load or 8 amperes intermittently, and up to 220 volts. It can be operated by hand, by mechanical means, or again by electromagnetic agency such as the usual telephone relay. This contact, developed and manufactured in Germany, and now introduced and sold by the Burgess Battery Company, is especially well adapted for use in telegraph and telephone systems, railway signaling and switching systems, fire alarm and burglar alarm systems, thermostats, traffic signals, controllers, advertising signs, rectifiers, electric ranges and other applications where a considerable wattage must be controlled by a minimum of energy.

The accompanying diagram presents the operating details of the vacuum contact. It will be noted that the principle is extremely simple. It makes use of the elastic property of glass to cause the mechanical actuation of contacts sealed in vacuum. The bellows *B*, because of their shape and the tempering of the glass, are highly elastic. A slight movement of the stem or protruding rod *C* is communicated to the movable contact block *E*, causing it to separate from contact block *G* which is stationary. The spring *E* makes positive contact between the contacts when no pressure is applied to the stem. The contacts are maintained in the evacuated glass tube *A*. The leads are indicated at *I*.



Operating in a vacuum, the vacuum contact is free from serious arcing and corroded contacts. It can handle its rated current as fast as 40 breaks per second. The make and break are positive and clean, without the hang-overs and chattering experienced with other forms of contacts, as proved by comparative oscillograph recordings. The vacuum contact requires a movement of only 0.02 inch at the end of its stem, which can be brought about by a force of less than 10 ounces, and usually but 6 ounces. The temperature rise at the rated current is extremely slight. The circuit is broken without arcing at less than 0.001 inch separation of the contact blocks. The small movement and slight force required for operation, lowers the total cost by the elimination of mechanical links. As for life, one of these contacts has been operated, at a rate of 10 times per second, 124,000,000 times without breakdown.

The Burgess vacuum contact is conservatively rated to handle 6 amperes at 220 volts, or 1320 watts, on continuous load. It will handle 8 amperes intermittently. The energy controlled is therefore of the order of two horsepower, controlled by the slightest pressure on the glass stem. There is no spark or arc, although on inductive loads a condenser is shunted across the contact. This device represents an ideal means of breaking heavy A. C. or D. C. currents with safety, rapidity and small force.

The normal action of the vacuum contact is with contact blocks in positive contact. A slight pressure on the stem breaks the circuit. However, this action can be reversed by mounting the contact with a pressure on the stem normally to break the circuit. Releasing the pressure will cause the circuit to close. Either method of control is practical. The ideal method of operating the vacuum contact is by means of a single electromagnet relay or telephone type relay, the armature of which is coupled to the end of the vacuum contact stem. The vacuum contact is clamped to the relay by suitable means.

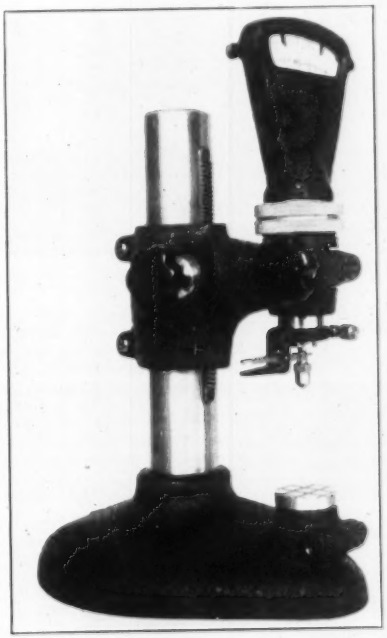
With the early availability of an entirely new form of light-sensitive cell, the vacuum contact promises to play an important role in the light control of many electrical circuits. The vacuum contact makes possible the operation of powerful equipment by means of light control, with an absolute minimum of equipment. The vacuum contact may be operated by a simple telephone type relay operating in the plate circuit of an amplifying tube fed by the output of the light-sensitive cell circuit, or again by a sensitive polarized relay actuated by the cell and in turn controlling the telephone relay which operates the vacuum contact for controlling over a thousand watts if necessary.

New Société Genevoise Micro-Indicator Stand

(R. Y. Ferner Co.)

A NEW stand for inspection purposes is being placed on the market by the Société Genevoise d'Instruments de Physique of Geneva, Switzerland. This stand, to be known as U-3, is designed for use with their fan-shaped Micro-Indicator in which a knife-edge multiplication system is employed.

The stand has an oval-shaped base approximately 10" long and $7\frac{1}{2}$" wide at its widest point and rests on 3 rubber feet. The base and the other iron parts of the stand are finished in crystalline lacquer. A socket integral with the base is provided at the forward end which is bored accurately to a standard size to provide for the interchangeable mounting of different types of lower anvils or tables.



In the illustration is shown a table hardened and lapped optically flat. This is $1\frac{5}{8}$" in diameter and is made with crossed grooves to make it easy to wring a standard flat-surfaced gage on the anvil in setting the instrument to zero before beginning readings. The column of the instrument is 2" in diameter and is fitted with a rack for quick adjustment of the arm to the right height by use of a pinion in the arm. The pinion is mounted in an eccentric bearing for accurate adjustment of the pinion to engage the rack smoothly.

A heavy clamp at the rear of the column serves to clamp the arm securely when it has been set at the proper height. The arm supporting the micro-indicator can be adjusted through a range of 6" and since the axis of the indicator is 3" from the column, cylindrical parts as large as 6" in diameter may be tested on this stand.

The micro-indicator itself is mounted in the arm through an adjustment ring on the upper part of the supporting arm. By rotation of this ring the fine setting of the micro-indicator on the stand gage can be readily accomplished. When the setting is made a special type of clamp secures the indicator firmly in the arm without vertical shift. The micro-indicators for use with these stands are supplied graduated to 1/2000, 1/5000, 1/10000 or 1/20000 inch per division, as desired, and have ample range to cover a wide range of tolerance. Adjustable tolerance marks are provided in these indicators so that rapid inspection of parts can be carried out on these stands or they can be used for very accurate comparisons of gages or parts for which the greatest precision is demanded.

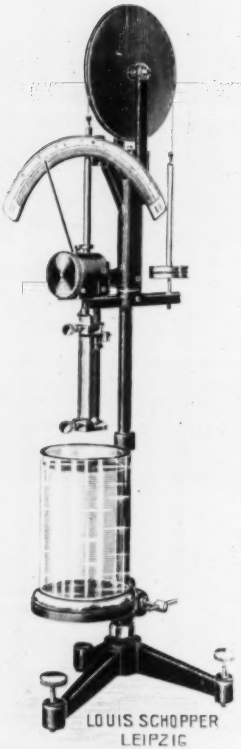
When desired an adjustable square can be furnished as an accessory of these stands. This square is secured to the column and can be set at any height to serve as a stop piece against which the pieces being tested can be rolled or placed to put them in the right position for measurements on all cylindrical parts, for example, at the high point of a diameter or at any other desired point on pieces of other shapes.

This stand with its optically flat table is adapted to the checking of cylindrical parts such as bushings, wrist pins, pistons or small axles, or for testing small flat pieces. Flat or cylindrical gages, including Go and No-Go gages can be easily compared, or can be checked in the process of grinding.

The stand is $13\frac{3}{4}$" high and weighs 32 lbs.

Stretch and Shrinkage Testing Apparatus

(H. Z. Schniewind)



THIS apparatus has been designed to measure the stretch of paper when moistened and its shrinkage when dried. These properties are of importance for multi-color printing, since size and shape of the sheet between printings will always put the various colors out of register. Also the makers and users of map papers, monotype, music roll and cartridge papers etc. are often handicapped by such troublesome changes. These can, however, be reduced to a minimum through selection of the proper pulp and through appropriate manufacturing methods. Therefore our new apparatus which enables the paper maker to determine and continuously supervise the effect of moisture upon stretch and shrinkage of paper during the manufacturing process is indispensable in the test-room of an up-to-date paper mill.

The strip under test is secured between 2 clamps, the lower of which is fitted to the end of a rigid rod permanently secured to the stand. The upper clamp is attached to a tension rod to which is fixed a thread passing over a pulley and carrying an adjustable weight. The upper clamp is also connected to the recording device which indicates the stretch or shrinkage. The stretch or shrinkage is indicated by a pointer which moves from its zero position, in the center between the 2 scales on the graduated quadrant, either to the right or to the left. Both scales are graduated to read from 0 to 5 mm. by 1/20 mm. The testing length of the strip is 100 mm. and the width 15 mm. Each division of the graduation is equal to 1/20% stretch or shrinkage.

The strip is moistened by immersion in a beaker of water. This beaker is carried on a movable support and can be conveniently lowered clear of the strip, or raised so as to immerse the latter.

Instead of the beaker of water, a container can also be used, through which a stream of moist or dry air is allowed to pass. The whole tester can also be enclosed in an atmosphere of known humidity.

New Measuring Microscopes

(George Scherr Co.)

THE Zeiss Works have recently placed on the market 2 new models of measuring microscopes, in both of which the microscope tube is traveled for obtaining the measurements, not the stage or work respectively. The smaller type, Model II (Fig. 1) has a range of 10 mm. the larger type, Model III (Fig. 2) has a range of 50 mm. The micrometers of both sizes read directly in 1/100 mm.

Both sizes use the same microscope tube. The ocular is a 7x Huygens eye-piece with hair line cross, and by means of different objectives total magnifications of 14x, 21x, 42x and 56x are available.

In the Model II the stand is fork-shape, on which a removable plate rests which serves as table. The member which carries the slide and microscope tube is clamped to the stand and it is removable, so that it can be used in a

Fig. 1

special fixture if desired. The micrometer barrel is chromium-plated to a dull finish, which greatly facilitates the reading, as it eliminates all glare.

In the Model III, the base of the stand is also fork-shape and arranged for receiving a Reflector for illumination from below. The round column carries both the member with the slide and microscope tube as well as a special bracket which serves as table. This can be swung out of the way and the slide with microscope tube can be removed from the column for use in a special fixture, where necessary.

On account of the fork-shape base, both the Models II and III can be placed directly on the work, wherever the work is too large to bring it to the table of the instrument.

The microscope serves for observing and measuring Brinnell impressions, scales, graduations, distances, etc.

In addition to the measuring microscopes described, the Zeiss works have also brought out a plain microscope, Model I (Fig. 3). This is also available with different magnifications.

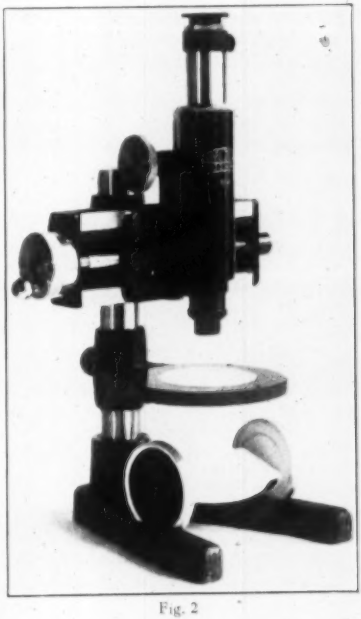


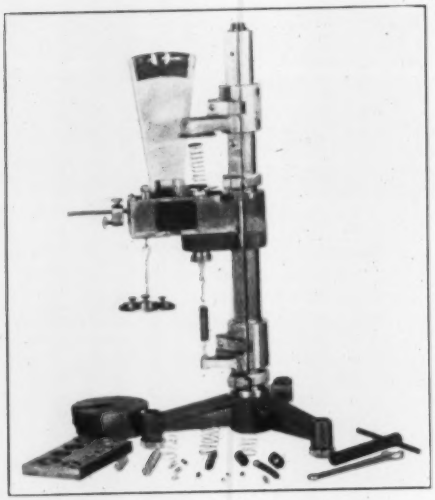
Fig. 2

Fig. 3

Elasticometer Spring Testing Machine, Type RS 2

(Coats Machine Tool Co.)

THE Elasticometer, type RS 2 works on knife-edges and has been designed to satisfy the demand for a machine particularly suitable for the quick inspection of light springs. Since the machine has a maximum load capacity of only 5 lbs., the scale consists of a single lever in the ratio of 1:1. From the outer end of this beam or lever, the weight-carrier is suspended whereas the inner end supports a bar, guided in steel balls, which carries a compression plate or platform above and a tension hook below. A pointer, directly fastened to the beam, completes the weigher scale which latter is enclosed in a housing, slideably arranged on the pillar of the machine and to which it may be clamped. Tension and compression tests are made by means of slides. Adjustable stops limit the motion of these slides for quantity inspection. A water level is provided on top of the pillar indicating horizontal alignment of the tripod base.



Only the main knife-edge is mounted in the Elasticometer when the machine leaves the plant. The remaining parts of the weigher mechanism are wrapped separately and packed in a box. They are readily assembled. This not only prevents damage in transit, but also makes for easy accessibility, permitting periodic inspection and cleaning of the weighing mechanism.

The load is determined by placing loose weights on the weight-carrier. Variations in length are read in 1/16″ on the vertical length scale engraved directly upon the pillar in such a way that the actual length of the spring in either its free, compressed or elongated state is indicated. Movable tolerance markers for length slide in a groove of the pillar whereas tolerance markers for weight are mounted close to the top of the fan-shape housing directly above the scale over which the indicating hand slides.

Automatic Oscillograph

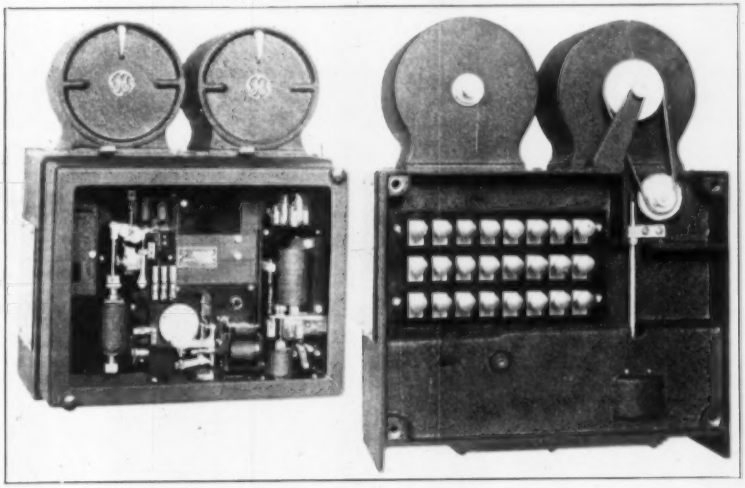
(General Electric Company)

TRANSIENT disturbances on electric power systems, such as accidental short circuits and similar phenomena, are recorded automatically by a new oscillograph. The instrument provides definite information of magnitudes of current obtained during accidental short circuits, thereby affording a check on short-circuit calculations, on the rupturing duty imposed on circuit breakers, and on relay settings. The device also provides a continuous check on relay operation. With the advent of high-speed switching and relaying, it provides the only precise means of keeping a continuous check on the actual speed of the relays and circuit breakers under operating conditions, and thereby the means for detecting and correcting any difficulties which may develop.

A development model of the new oscillograph was used during some staged system tests, when records were also made with standard oscillographs. The automatic oscillograph performed perfectly, in one or two cases obtaining records which the standard oscillograph did not obtain because of a misunderstanding in the correlation between the times of throwing on the short circuit and of starting the standard oscillographs. The automatic oscillograph

was installed later on an operating system, and many records of transient disturbances were obtained.

The new oscillograph, designated as Type PM-13-A1, contains 6 oscillograph galvanometers of standard construction, and makes a truly oscillographic record on sensitized paper 4¼" wide. The unique feature of the instrument is in its ability to start the record in less than a half cycle. The instrument is designed for mounting either on a table in the usual way or on a switchboard panel in case it is desired to install it as a piece of permanent station equipment. For this purpose the connection binding posts on the back are replaceable by studs which project through the panel for making connections to the back.



The record is made not on standard photographic film but on a special bromide paper obtainable in 200-foot lengths, with the exposed and unexposed rolls of paper stored in 2 magazines on top of the instrument. Indicators show the amount of paper in each magazine.

The oscillograph operates automatically without attention until the 200 feet of paper have been exposed. Arrangements have been made, however, so that at any time and without disturbing the unexposed paper, the exposed portion may be cut off and developed so that a disturbance may be studied immediately after it has occurred. To correlate records with system disturbances, the instrument has contacts to give an indication by bell or annunciator each time it operates, and with a counter which counts the operations so that the station operator can note the date and time of each operation along with the record number, thereby identifying each record.

The oscillograph is put into operation by neutral current. The starting relay starts the motor which drives the paper, and at the same time puts in motion a mirror arrangement by which the light beams are swept along the paper in a direction opposite to its motion during the period in which the paper is coming up to speed. By this means the record is started in less than a half cycle and, by properly correlating the motion of the mirror to the accelerating characteristics of the paper, a reasonably uniform time axis is obtained throughout the whole record.

The film speed is approximately 12"/sec., so that 200 seconds of exposure can be obtained without changing the film. The oscillograph will run for predetermined times, adjustable from 2 seconds minimum to 20 seconds maximum. If at the end of the predetermined period of operation the disturbance which initated the operation of the oscillograph is still present on the system, the record will be continued without interruption for another similar period. A three-phase wattmeter element, available in case a record of power is desired, can be installed in place of two of the standard elements.

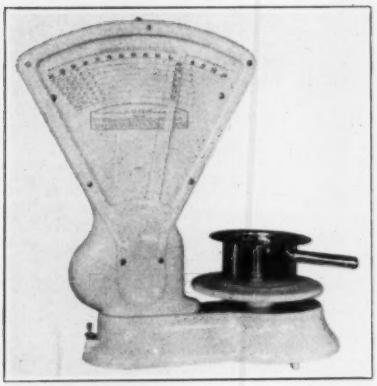
Light is furnished by a standard 6-volt, 32-candlepower automobile headlight lamp which burns continuously. Power for operating the lamp and for driving the motor can be obtained from a six-volt automobile storage battery that is floated continuously across a small battery charger whose output can be adjusted to exceed slightly the current required by the lamp. In this way, the battery is kept continuously in readiness for operation, without attention except for a periodical inspection at intervals of two weeks.

Ice Cream Over-run Auto-gage

(Toledo Precision Devices, Inc.)

THE Toledo ice cream over-run auto-gage is designed to show the percentage of mix displaced by air in the freezing operation, using 1 pint sample of mix.

The cup on the auto-gage platter is filled with unfrozen mix. The indicator will come to rest on or near one of the zeros on the right hand side of the chart. Adjacent to this zero on the indicator will be shown the weight per gallon of the mix. Let us assume this to be 9.2 lbs.



The top row of graduations on the chart shows the actual weight of the pint of mix, which in this case is slightly more than .15 lbs. as shown by the indicator. The weight per gallon, 9.2 lbs., is made note of and the freezing operation is started.

Tests are made by filling the cup with frozen cream and placing it on the platter of the auto-gage. The percentage of overrun will be indicated on the graduatedpercentage reading line adjacent to the line on the indicator representing the weight per gallon.

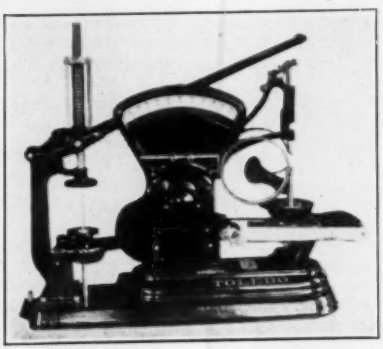
Tests are continued until the desired percentage of overrun is obtained when the freezing operation is completed. The overrun for 9.2 lbs. per gallon of mix is 99½%.

This auto-gage will show the actual weight of 1 pint of mix in terms of 1/100 lb. the actual weight of 1 gallon of mix in terms of 1/10 lb.; the actual weight of 1 pint of frozen cream in terms of 1/100 lb.; the weight per gallon of frozen creams of 1/10 lb.; and the percentage of over-run.

Piston Ring and Valve Spring Auto-Gage

(Toledo Precision Devices, Inc.)

THE combination piston ring and valve spring auto-gage is designed to compare the strength of piston rings and to gage the compression strength of valve springs of an engine. This device is for the use of automobile, airplane, piston ring, valve spring manufacturers, and all makers and users of the small internal combustion engines whose high standards of uniformity for their products necessitate the most exacting tests.



Uniform piston ring pressure is of the utmost importance in keeping the cylinder wear down to a minimum and for preventing excessive piston ring blowing and oil pumping. If the ring is too stiff and exerts a greater pressure against the cylinder walls than that necessary for best performance, the rate of piston ring and cylinder wear will be increased. If the ring is too weak it will not form an effective seal between the combustion chamber and the crank case. This causes dilution of the lubricating oil, excessive carbon formation and loss of power.

A proper strength in valve springs prolongs the life of the valve cams, rollers, rocker arms and valve seats and maintains a better power balance. If the spring is too

stiff it requires a greater force to open it than is necessary, thereby causing faster wear on the above-mentioned parts. If the spring is too weak there is danger of the valve holding open, thereby increasing the possiblity of burning the valve seats with consequent loss of power. If the spring is weak enough to allow the roller to leave the cam, the compression pressure will cause the valve to close suddenly and come against the seat with a hard impact, causing noise and excessive wear. Too weak a spring will also allow the admission valve to hold open too long at high speeds causing misfiring and backfiring in the admission manifold.

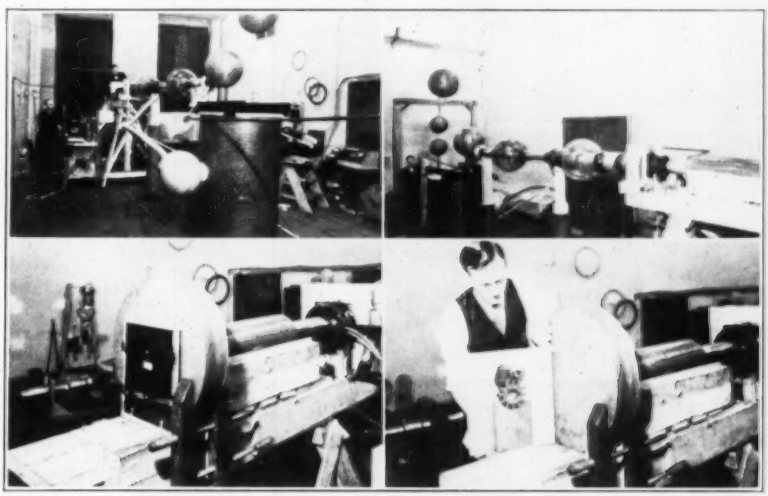
The auto-gage is adjustable to any size piston ring. When the ring is in place and the lever compressed, the resistance of the piston ring is read directly from the chart using the bottom black figures.

To gage a valve spring, slip the spring over the removable spindle after the proper adjustments have been made and bring the long handle down against the stop. The compression strength of the spring is then read directly from the red upper line of figures on the chart.

This machine is designed for use in connection with the testing of piston rings and valve springs which are generally used in the automotive and airplane industries. It is also adaptable for other similar uses.

The Most Powerful X-Ray Tube

X-RAYS at 900,000 volts—the highest voltage ever attained in a tube built for continuous operation—are produced in the large two-section x-ray tube which has been built in the Research Laboratory of the General Electric Company, Schenectady, by Dr. W. D. Coolidge, associate director of the laboratory.



Upper left hand photograph shows the tube with the cathode end in the foreground. The 900,000-volt induction coil, supplied by 1100 volts, is within the cylinder in the foreground. The sphere gap, regulating the voltage, is above. In the lower of the 2 brass spheres are the storage batteries for heating the filament, or hot cathode, of the tube.

Upper right hand photograph shows the tube with the target in the foreground, at the extreme right. The target is surrounded by a lead cylinder, one inch thick.

Lower left hand photograph shows casette, or x-ray film holder, in front of which are 3 gears to intercept the x-rays. (The gears are resting on a block of wood, which does not stop the x-rays). In front of the target of the tube have been placed many large discs of iron, to a total of four inches in thickness.

Lower right hand photograph shows the casette in place before the x-ray target, ready for a radiograph through the 4 inches of iron.

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GENERATOR UNITS. A 12 page publication identified as Circular 1908 describes four different types of generators used where a small amount of electrical energy is necessary, but where no central station supply is available. These generators are discussed from an apparatus and an application standpoint. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INTERFEROMETERS. A pamphlet entitled, "Memorandum on the Hilger Interferometers" which are used for the correction of optical work. Adam Hilger, Ltd. 24 Rochester Place, Camden Rd., London N. W. 1, England.

NAVIGATION LIGHTS. A circular describing the type 554 navigation light. They are fire-proof; non-inflamable material being used in their construction. Their construction and installation is described. Pioneer Instrument Co., 754 Lexington Ave., Brooklyn, N. Y.

MEASUREMENT OF INSULATION RESISTANCE. No. 1150 entitled, "Pocket Manual of Megger Practice" deals with electrical insulation and the applications and uses of "Megger" insulation testing instruments James G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

AIRPORT LIGHTING. Catalogue No. 218-FA describes the construction and application of airport lighting equipment. Photographs and drawings supplement the text. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INDICATING THERMOMETERS. Bulletin No. 148-2 is a 32-page booklet describing each type of Foxboro Indicating Thermometer. Contains valuable information on dials, ranges, bulbs, tubing, gageboards and other details, and pictures of typical installations. The Foxboro Co., Foxboro, Mass.

COMPRESSION FITTINGS. Bulletin No. 13 describes the application, advantages and installation of Dieform Compression Fittings when used with copper or steel tubing for small service lines. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

WEATHERING CABINETS. A booklet describing the various types of accelerated weathering cabinets. It is completely illustrated. Atlas Electric Devices Co., 360 W. Superior St., Chicago, Ill.

GAS SERVICE JOURNAL. No. 4, Vol. 5 of this publication contains the following articles: "Positive Displacement Gas Meters," "The Power Companies," "Possible Utilization of Natural Gas for the Production of Chemical Products", and "Pressure Regulators and Boosters." Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

STEELOSCOPE. A 9 page booklet describing the Hilger Steeloscope and its use for the rapid estimation of nickel, chromium, molybdenum, manganese, copper tin, etc. Adam Hilger, Ltd., 24 Rochester Pl., Camden Rd., London N. W. 1, England.

POTENTIOMETERS. A circular describing and illustrating potentiometers for every class of electrical measurement. Gray Instrument Co., 64 West Johnson St., Philadelphia, Pa.

STOP WATCHES AND SPLIT-SECOND TIMERS. A circular describing watches and timers and their uses. The Sterling Stop-Watch Co., Inc., 15 East 26th St., New York.

PYROMETER TUBES. Bulletin 431 entitled, "X-Ray Inspected Metal Pyrometer Tubes." Claud S. Gordon Co., 708 W. Madison St., Chicago, Ill.

HYDROMETER. A leaflet describing the boiler blowoff hydrometer, which enables one to read the density of blowoff at any temperature. The Permutit Co., 440 Fourth Ave., New York.

GAGES. A circular describing style 9042 and style 9033 the former developed to increase the speed and accuracy in gaging large holes and the latter an improvement for checking shoulder work. Taft-Pierce Mfg. Co., 32 Mechanic Ave., Woonsocket, R. I.

WHY WASTE STEAM? is the title of a circular by Sarco Company, Inc., 183 Madison Ave., New York.

PRICE LIST. The April 16, 1931 price list gives the price of Baker's Industrial Chemicals. J. T. Baker Chemical Co., Phillipsburg, N. J.

SPECTRUM ANALYSIS IN MINERALOGY This is the title of a 52 page booklet by A. A. Fitch, and published by Adam Hilger, Ltd., 24 Rochester Place, Camden Road, London N. W. 1, England. Price 1s. 11d. postpaid.

POTENTIOMETER PYROMETER. A circular entitled Putting the L & N Electrical Balance to Work on Industrial Heat Control. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

SPECTROSCOPIC INSTRUMENTS. A series of leaflets entitled, Vacuum Iron Arc Lamp, Spectrogrgph of Great Intensity and Bolometer for the X-Ray Region up to 0.1A.U. P. J. Kipp & Zonen, Delft, Holland.

PORTABLE BRINELL MACHINE. No. 6 circular describes and illustrates portable Brinell testing apparatus and similar testing devices for pressures of 1650, 2200, and 6600 lbs. Alfred Suter, 200 Fifth Avenue, New York.

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Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

IMPACT HARDNESS TESTER
Alfred Suter

IMPACT TESTING MACHINES
Alfred Suter

Alternating

INDICATORS—See Gages

INDUCTANCES
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

INSTRUMENT CALIBRATION AND REPAIRS
Amthor Testing Inst. Co.
Claud S. Gordon Co.
Jewell Electrical Instrument Co.
Rubicon Company
Weston Elec. Inst. Corp.

INSTRUMENT FUSES
Littlefuse Laboratories

INSTRUMENT OILS
William F. Nye, Inc.

INSTRUMENT TRANSFORMERS
Jewell Electrical Instrument Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.

INSULATION TESTING EQUIPMENT
Leeds & Northrup Co.
Rubicon Company
Westinghouse Elec. & Mfg. Co.

INTEGRAPHS & INTEGRATORS
Leeds & Northrup Co.

INTERFEROMETERS
Gaertner Scientific Corp.

INVERTED CONVERTERS
Bodine Electric Co.

JOB TIMING RECORDERS

KEYS AND SWITCHES
General Radio Co.
Leeds & Northrup Co.
Rubicon Company

KILNBOY
Foxboro Co.

KILOVOLT AMPERE METERS

KLYDONOGRAPHS
Westinghouse Elec. & Mfg. Co.

LABORATORY WASHING MACHINES
Atlas Electric Devices Co.

LACTOMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

LAUNDER-OMETER
Atlas Electric Devices Co.

LENGTH MEASURING MACHINES
R. Y. Ferner Co.
Gaertner Scientific Corp.

LEVELS
Centering
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Engineer's, Wye, Precision, Prism
R. Y. Ferner Co.
Taylor Instrument Companies

LIQUID METERS
Buffalo Meter Co.

LOCOMOTIVE INDICATORS

LUSTER METERS

MACHINE OILS
William F. Nye, Inc.

MAGNETOMETERS
Rubicon Company

MANOMETERS
Brown Instrument Co.
Foxboro Co.
Meriam Co.
Alfred Suter

MASTER CLOCKS
Gaertner Scientific Corp.

MEGOHMMETERS
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Rubicon Company

MEGOHM VOLTMETERS
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

MELTINGPOINT APPARATUS
Claud S. Gordon Co.
Tagliabue Mfg. Co., C. J.

METER PROVERS, Gas

METER TESTERS, Gas

MICROMETERS
Amthor Testing Inst. Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

MICROAMMETERS
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.

MICROFARADMETERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

MICRO PYROMETERS

MICROSCOPES
Brinell
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Claud S. Gordon Co.
Spencer Lens Co.
Alfred Suter
Measuring
R. Y. Ferner Co.
Metallographic
Bausch & Lomb Optical Co.
Claud S. Gordon Co.
Spencer Lens Co.
Petrographical
Bausch & Lomb Optical Co.
Spencer Lens Co.
Toolmakers'
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.
Spencer Lens Co.

MICROTOMES
Bausch & Lomb Optical Co.
Spencer Lens Co.

MILLIAMMETERS
General Radio Co.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Weston Electrical Inst. Corp.

MILLIVOLTMETERS
Bristol Company
Brown Instrument Co.
Illinois Testing Labs., Inc.
Jewell Electrical Instrument Co.
Rawson Electrical Instrument Co.
Taylor Instrument Companies
Weston Electrical Inst. Corp.

MOTOR RADIATOR VALVES
Minneapolis-Honeywell Co.

MOTION RECORDERS
Mechanical
Bristol Company
Foxboro Co.

MOTORS
Bodine Electric Co.

MOTOR GENERATOR SETS
Bodine Electric Co.

MULTIMETERS
Rawson Electrical Instrument Co

MULTIPLIERS
Jewell Electrical Instrument Co
Leeds & Northrup Co.
Weston Electrical Inst. Corp.

NEON FILLED TUBES

NEPHELOMETERS
Spencer Lens Co.

OHM METERS
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Rubicon Company
Weston Electrical Inst. Corp.

OILS
William F. Nye, Inc.

OIL METERS
Buffalo Meter Co.
Claud S. Gordon Co.

OIL TESTING APPARATUS
Atlas Electric Devices Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

OPERATION RECORDERS
Electrical
Bristol Company
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

ORIFICE METERS
Brown Instrument Co.
Foxboro Co.
Meriam Co.

ORSAT APPARATUS

OSCILLOGRAPHS
General Radio Co.
Westinghouse Elec. & Mfg. Co.

OXYGEN RECORDERS
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

PAINT TESTING INSTRUMENTS
Atlas Electric Devices Co.

PANTOGRAPHS
Gaertner Scientific Corp.

PAPER TESTING INSTRUMENTS
Atlas Electric Devices Co.

PERFORMANCE METER

PERMEAMETERS
Leeds & Northrup Co.
Rubicon Company

PAPERTESTINGINSTRUMENTS
Amthor Testing Inst. Co.
Spencer Lens Co.

PERISCOPES
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

PHASE INDICATOR
Westinghouse Elec. & Mfg. Co

PHASE SEQUENCE INDICATOR

PHONOGRAPH TURNTABLES, Electric
Bodine Electric Co.

PHOTOELECTRIC COLOR ANALYZERS

PHOTOELECTRIC COLOR COMPARATOR

PHOTO-ELECTRIC TUBES
Westinghouse Elec. & Mfg. Co

PHOTOMETERS
Gaertner Scientific Corp.
Bausch & Lomb Optical Co.
Leeds & Northrup Co.

PHYSICAL TESTING MACHINES
Amthor Testing Inst. Co.
Atlas Electric Devices Co.
Claud S. Gordon Co.
Southwark Fdry. & Mach. Co.
A. Suter

PITOT TUBE METER
Brown Instrument Co.
Foxboro Co.

PLANIMETERS
Automatic Flow Record
Brown Instrument Co.
Foxboro Company
Linear
Brown Instrument Co.
Radial
Bristol Company
Foxboro Co.
Square Root
Foxboro Co.

POLARISCOPES
Gaertner Scientific Corp.

POSITION RECORDERS
Bristol Company
Foxboro Co.

POTENTIAL DETECTORS
Leeds & Northrup Co.
Westinghouse Elec. & Mfg. Co.

POTENTIOMETERS—Indicating
Brown Instrument Co.
Claud S. Gordon Co.
Leeds & Northrup Co.
Rubicon Company

Recording & Controlling
Claud S. Gordon Co.
Leeds & Northrup Co.

POWER FACTOR METERS
Jewell Electrical Instrument Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.

POWER FACTOR REGULATORS
Westinghouse Elec. & Mfg. Co.

PRESSURE RECORDERS
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

PROCESS TIMING AND SIGNALING INSTRUMENTS
Bristol Company

PROGRAM INSTRUMENTS
Automatic Temp. Control Co.
Leeds & Northrup Co.

PROJECTION LANTERNS
Bausch & Lomb Optical Co.
Spencer Lens Co.

PROTRACTOR
Optical
Bausch & Lomb Optical Co.

PSYCHROMETER
Recording
Bristol Company
Foxboro Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Sling
Taylor Instrument Companies

PYROMETERS
Optical
Claud S. Gordon Co.
Leeds & Northrup Co.

Radiation
Indicating
Brown Instrument Co.
Claud S. Gordon Co.
Leeds & Northrup Co.
Taylor Instrument Companies

Recording
Brown Instrument Co.
Leeds & Northrup Co.
Taylor Instrument Companies

Thermo-electric
Immersion
Bristol Company
Brown Instrument Co.
Claud S. Gordon Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Taylor Instrument Companies

Indicating
Bristol Company
Brown Instrument Co.
Claud S. Gordon Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Taylor Instrument Companies
Westinghouse Elec. & Mfg. Co.

Recording and Controlling
Bristol Company
Brown Instrument Co.
Claud S. Gordon Co.
Leeds & Northrup Co.
Taylor Instrument Companies

Surface Contact
Bristol Company
Brown Instrument Co.
Claud S. Gordon Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.
Taylor Instrument Companies

RADIO FREQUENCY OSCILLATORS
General Radio Company
Jewell Electrical Inst. Co.

RADIO SET ANALYZERS
General Radio Company
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

RADIO TUBE CHECKERS
General Radio Company
Jewell Electrical Instrument Co.
Weston Electrical Inst. Corp.

RADIO TEST PANEL
Jewell Electrical Instrument Co.
Rubicon Company
Weston Electrical Inst. Corp.

REFRACTOMETERS
Bausch & Lomb Optical Co.
Spencer Lens Co.

REGULATORS—See Controls

RELAYS
General Radio Co.
Claud S. Gordon Co.
Jewell Electrical Instrument Co.
Minneapolis-Honeywell Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.

REMOTE METERING EQUIPMENT
Bristol Company
Brown Instrument Co.
General Electric Co.
Leeds & Northrup Co.
Westinghouse Elec. & Mfg. Co.

RESISTANCE—Electrical
General Radio Co.
Leeds & Northrup Co.
Rubicon Company
Spencer Lens Co.

RHEOSTATS
General Radio Co.
Rubicon Company
Spencer Lens Co.

ROTOSCOPE

RUBBER TESTING INSTRUMENTS

SACCHARIMETERS
Bausch & Lomb Optical Co.
Spencer Lens Co.
Taylor Instrument Companies

SACCHAROMETERS
Tagliabue Mfg. Co., C. J.

SALINITY INDICATORS
Leeds & Northrup Co.
Rubicon Company

SCALES
Amthor Testing Instrument Co.
Gaertner Scientific Corp.
Alfred Suter

SCRATCH HARDNESS TESTER

SEISMOGRAPHS
R. Y. Ferner Co.

SERVICE RECORDERS

SHUNT METERS
Bristol Co.

SHUNTS
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rubicon Company
Weston Electrical Inst. Corp.

SIGNALING DEVICES—Automatic
Brown Instrument Co.
Leeds & Northrup Co.
Rubicon Company

SLIDE RULES

SLOW SPEED MOTORS
Bodine Electric Co.

SMOKE INDICATORS & RECORDERS
Leeds & Northrup Co.
Westinghouse Elec. & Mfg. Co.

SOIL PRESSURE CELLS

SPECIAL INSTRUMENTS
Amthor Testing Inst. Co.
Burgess-Parr Co.
Meriam Co.

SPECIAL ELECTRICAL INSTRUMENTS
Atlas Electric Devices Co.
Bristol Co.
Brown Instrument Co.
General Radio Co.
Illinois Testing Labs., Inc.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Rubicon Company
Weston Electrical Inst. Corp.

SPECIAL RECORDING DEVICES

SPECIFIC GRAVITY APPARATUS—Gas

SPECTROGRAPHS
R. Y. Ferner Co.
Gaertner Scientific Corp.

SPECTROSCOPES
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.
Spencer Lens Co.

SPECTROPHOTOMETERS
Bausch & Lomb Optical Co.
Gaertner Scientific Corp.

SPEED INDICATORS
See Tachometers

SPEED RECORDERS
Amthor Testing Inst. Co.
Brown Instrument Co.
Leeds & Northrup Co.

STANDARD CELLS
Weston Electrical Inst. Corp.

STEEL TAPES

STOP WATCHES
R. Y. Ferner Co.

STRAIN GAGE
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Alfred Suter

STRESS INDICATOR

STROBOSCOPES

SULPHUR DIOXIDE METERS
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.

SULPHUR DETERMINATION APPARATUS
Burgess-Parr Co.
Tagliabue Mfg. Co., C. J.

SUNSHINE RECORDERS
Leeds & Northrup Co.
Taylor Instrument Companies

SURGE RECORDERS

SYNCHRONIZING FORKS—Electrical
General Radio Co.
Leeds & Northrup Co.

SYNCHRONOUS MOTORS
Bodine Electric Co.

TACHOSCOPES
Amthor Testing Inst. Co.
Brown Instrument Co.

TACHOMETERS
Amthor Testing Instrument Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.

TELESCOPES
Bausch & Lomb Optical Co.
R. Y. Ferner Co.
Gaertner Scientific Corp.

TENSILE TESTERS FOR PAPER WIRE, SHEETS, ETC.
Amthor Testing Instrument Co.
Alfred Suter

TENSOMETER (Huggenberger)
Southwark Fdry. & Mach. Co.

TESTERS, Gas

TESTING MACHINE

Portable—Tensile—Compression
Southwark Fdry. & Mach. Co.

Universal
Amthor Testing Inst. Co.
Claud S. Gordon Co.
Southwark Fdry. & Mach. Co.
A. Suter

TEXTILE TESTING INSTRUMENTS
Atlas Electric Devices Co.
A. Suter

THEODOLITES

THERMO-JUNCTIONS(Electric)
General Radio Co.
Rawson Electrical Instrument Co.

THERMOMETERS

Gas Filled
Bristol Company
Brown Instrument Co.
Foxboro Co.
Claud S. Gordon
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Mechanical
Brown Instrument Co.
Foxboro Co.
Tagliabue Mfg. Co., C. J.

Mercurial
Bristol Co.
Claud S. Gordon Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Resistance
Brown Instrument Co.
Claud S. Gordon Co.
Illinois Testing Labs., Inc.
Leeds & Northrup Co.

Vapor-Tension
Bristol Company
Brown Instrument Co.
Foxboro Co.
Claud S. Gordon Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Wet & Dry Bulb
Bristol Company
Brown Instrument Co.
Foxboro Co.
Claud S. Gordon Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

THERMOSTATS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Claud S. Gordon Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

TIME OPERATION RECORDERS
Bristol Company
Foxboro Co.
Claud S. Gordon Co.
Tagliabue Mfg. Co., C. J.

TIME RECORDERS
Bristol Company
Brown Instrument Co.
Gaertner Scientific Corp.
Claud S. Gordon Co.
Foxboro Co.

TIME SWITCHES
Claud S. Gordon Co.
Westinghouse Elec. & Mfg. Co.

TIMERS
Automatic Temp. Control Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Rubicon Company

TINTOMETER

TORSIOGRAPH

TORSION MACHINES
Alfred Suter

TRANSFORMATION POINT RECORDERS
Brown Instrument Co.
Leeds & Northrup Co.

TRANSFORMERS
General Radio Co.
Weston Electrical Inst. Co.

TRANSITS

Engineer's, Surveyors, Mine
Gaertner Scientific Corp.

Pocket
Taylor Instrument Companies

TUNING FORKS—Electrically Driven
General Radio Co.
Gaertner Scientific Corp.
Leeds & Northrup Co.
Rubicon Company

TURBIDIMETERS
Burgess-Parr Co.

U-TUBE MANOMETERS
Amthor Testing Inst. Co.
Meriam Co.

VACUUM RECORDERS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Taylor Instrument Cos.

VACUUM TUBE BRIDGES
General Radio Company

VALVES

Automatic Shut Off
Automatic Temp. Control Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Claud S. Gordon Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

Balanced
Automatic Temp. Control Co.
Brown Instrument Co.
Foxboro Co.
Claud S. Gordon Co.

Diaphragm
Bristol Company
Foxboro Co.
Claud S. Gordon Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Electrically Operated
Automatic Temp. Control Co.
Bristol Company
Brown Instrument Co.
Claud S. Gordon Co.
Minneapolis-Honeywell Co.

Reducing
Claud S. Gordon Co.
Tagliabue Mfg. Co., C. J.

Regulating
Automatic Temp. Control Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Claud S. Gordon Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

Safety, Fuel Shut-off
Claud S. Gordon Co.
Minneapolis-Honeywell Co.
Tagliabue Mfg. Co., C. J.

VENTURI METERS
Brown Instrument Co.
Foxboro Co.

VIBROGRAPH

VIBROSCOPE

VISCOSIMETERS
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies

VISCOSITY TUBES

VOLTAGE DIVIDERS
General Radio Co.
Rubicon Company

VOLT-AMMETERS
Jewell Electrical Instrument Co
Westinghouse Elec. & Mfg. Co
Weston Electrical Inst. Corp.

VOLTMETERS

Indicating
General Radio Co.
Jewell Electrical Instrument Co.
Leeds & Northrup Co.
Rawson Electrical Instrument Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Inst. Corp.

Recording
Bristol Company
Leeds & Northrup Co.
Westinghouse Elec. & Mfg. Co

Thermionic, Oxide Rectifier
General Radio Co.

WATER METERS
Foxboro Co.

WATER METERS—Hot and Cold
Buffalo Meter Co.

WATER & SEDIMENT APPARATUS
Tagliabue Mfg. Co., C. J.

WATTHOUR METERS
Westinghouse Elec. & Mfg. Co

WATTMETERS

Indicating
Jewell Electrical Instrument Co
Rawson Electrical Instrument Co
Westinghouse Elec. & Mfg. Co
Weston Electrical Inst. Corp.

Recording
Bristol Company

WAVEMETERS
General Radio Co.

WAX MELTING APPARATUS
Tagliabue Mfg. Co., C. J.

WEAR-OMETER
Atlas Electric Devices Co.

WEATHER-OMETER
Atlas Electric Devices Co.

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